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VETERA ET NOVA

OR

EXTRACTS FROM THE DIARY OF A
MEDICAL PRACTITIONER

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L.

BIOLOGICAL PHYSICS PHYSIC & METAPHYSICS

STUDIES AND ESSAYS BY
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AND
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TO THE MEMBERS OF
THE WEST RIDING OF YORKSHIRE ABERDEEN UNIVERSITY
GRADUATES ASSOCIATION, OF WHICH DR. LOGAN
WAS THE FIRST PRESIDENT
AND
IN MEMORY OF THE LATE
SIR THOMAS GALBRAITH LOGAN, K.C.B.,
DIRECTOR-GENERAL OF BRITISH ARMY MEDICAL DEPARTMENT,
AND THE LATE
DRS. CHARLES SMITH
(UNCLE AND NEPHEW), NATIVES OF GIRVAN, AYRSHIRE,
AND FORMERLY MEDICAL PRACTITIONERS IN
NEWTON-STEWART, WIGTONSHIRE

NOTE

THE late Dr. Thomas Logan was born at Bargenoch, in the parish of Coylton, Ayrshire, and received his primary education there from the late Mr. John Smith, parochial schoolmaster, who was also the teacher of that Scottish genius the late George Douglas Brown, author of the *House with the Green Shutters*.

He then passed to Anderson's College, Glasgow, and received his Clinical training at the Royal Infirmary. He always retained a high appreciation for all his old Professors, to whom he was indebted for so much. In due time, after examination, he got his license to practise from the Royal Faculty of Physicians and Surgeons of that city. He then entered the University of Aberdeen, and after several years of study he graduated M.D. there. Afterwards he was appointed House-Surgeon to Paisley Infirmary, and after spending a short time in that institution went to general practice in the south of Scotland, and then to Yorkshire, where he spent the rest of his life. All through his professional career he was busily engaged as a general practitioner and public health officer.

He had the true scientific spirit, and was a great student till the end of his days, and was very well informed in geology, astronomy, and general literature. He was for many years a regular attender at all meetings of the British Medical Association, the International Congresses, and those of the British Association.

He travelled much, having visited nearly all the European capitals, besides travelling a great deal in America, and thus by means of his extensive and acute observation added greatly to his scientific and general knowledge. He was a man of splendid physique and of profound intellect, and satisfied his own mind on all topics in which he was interested. He was for long engaged in the work now presented, and it was his intention to see it through the press ; but unfortunately he was overtaken by a fatal illness, and in consequence this duty fell into other hands. He died at Harrogate in September, 1907, at the age of sixty-nine years. He was unmarried.

His MS. passed into the hands of his trustees, Alexander Gemmell, banker, Bradford, and Dr. Quintin M'Lennan, Glasgow, and but for the prolonged illness of the latter, the work would have been issued long ago. After a great deal of care, work, and anxiety on the part of his trustees it has now been completed.

Dr. M'Lennan, who has had a deep interest in it all along, and knew Dr. Logan's views with regard to it, had the great satisfaction and good fortune of having his friend, Dr. P. Henderson Aitken, of Oxford, as co-editor. They have done their part of the work to the best of their ability, and in accordance with Dr. Logan's strict wishes and instructions. No alterations or excisions of any of the text were permitted, and his wishes in that respect have been rigidly observed. Here the trustees' responsibility ceases, and the work is now put into the hands of the medical profession by them, in the hope that it will be cordially received.

The Editors have to express their indebtedness to Messrs. Longmans, Green & Co., Messrs. Macmillan & Co. Ltd., and the Clarendon Press, Oxford, for assistance by the loan of illustrations which the author had selected for this work.

Dr. Logan was a very highly esteemed member of the profession, and a man of lofty ideals and high personal character, and was beloved wherever he was known.

He now lies in the quiet churchyard of Coylton, in the burying-ground of his forefathers, which nestles at the foot of the Craigs o' Kyle, and in the very centre of the Burns country.

Dr. Logan was in active practice for well-nigh half a century, and before retiring received a public recognition of his professional ability and personal worth at the hands of the merchants and medical gentlemen of Bradford and neighbourhood.

PREFACE

Vetera et Nova, or 'Old and New,' fitly describes the character of the following pages and the materials used in their production, as well as the results arrived at in the way of constructive effort by the re-arrangement of them on lines dictated by re-interpretation of their individual and combined meaning when viewed apart and when placed in fresh relationships. The 'old' has thus been *used to construct* the 'new,' and whether the result may turn out a success remains to be seen, and whether so much fault-finding has been justified remains to be tested by the application to it of the usual canons of criticism and practical application of it to everyday requirements of those engaged theoretically or practically in working the departments of knowledge involved in the subjects dealt with.

No department of knowledge can remain stationary intrinsically, and much less so when regarded as an indispensable part of universal knowledge; it must therefore move forwards or backwards in obedience to forces working from within, and be moved from without according to its specific position in the great commonwealth of knowledge and the general alteration in relationship to its various departments. In the latter respect—the department of biological physics, it seems to us, has not changed its position to the extent that the movements of some of its later offshoots require in order that the

symmetry should be preserved and that there should be no retardation of the general progress ; for example, physiology is shooting ahead of anatomy ; pathology is fast overtaking physiology, and some of the later developments, such as bacteriology and hygiene, threaten to overrun and asphyxiate the foundation sciences from which they have sprung, and on which they still rely for support and encouragement.

The following pages, regarded as a contribution towards the rectification of this disproportionate progress, will, we hope, not be without some slight value, and, at any rate, that they will justify their submission to the republic of Science as an example of an always needed effort to widen and deepen the foundation of the great structure of knowledge—biological, medical, and metaphysical.

These ‘Extracts from the Diary of a Medical Practitioner’ were not originally intended for publication. They consequently bear no impress of effort at continuity of detail or treatment, or of closely reasoned and consecutive arrangement of subject, but have been grouped or *classified* and loosely thrown together somewhat in the chronological order of that original production, and as one subject suggested another, in easy and irregular sequence, during the course of many years.

Constituting thus but a series of fragments of asymmetrical proportions, and differing much in their degree of elaboration, they nevertheless lend themselves to a ‘mosaic arrangement’ and ‘scientific disposition’ in such a manner that a ‘definite pattern’ may become the ultimate result.

The bibliography involved in their production and elaboration, and the assignment of indebtedness for suggestions and ideas are now, we regret to say, impossible tasks, inasmuch as the ‘weft and the woof’ of their texture have been the product of daily reading, observa-

tion, reflection, and more or less severe study. Suffice it, therefore, to say that the original teaching which it was our privilege to obtain, the information we derived from the perusal of text-books and works of reference, as well as the ordinary 'serial literature of the period,' and the personal opportunities of gaining knowledge 'at first hand' which we have enjoyed, have been the source from which any truths they may contain were elaborated. For our indebtedness to all these 'non-personal' sources of knowledge, therefore, we take the opportunity of expressing our warmest thanks, and our sincerest apologies for our inability to mention individual names.

Moreover, we are well aware and are bound to acknowledge that, but for 'these non-personal' sources of information and the opportunities they have given of daily 'piecing together' the materials they supplied, it would have been altogether impossible for us to have systematised the facts and deduced the *views* which we have now, however imperfectly, ventured to put before those capable of appraising their scientific value and their practical bearings.

THOMAS LOGAN.



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INTRODUCTION.

To begin with, the phrase : *Circulatio circulationum omnia circulatio*, the sub-title of the following extracts, requires a few words of reference or explanation. After many years of observation and experience, and more or less consecutive thinking and study, the truth of the above generalisation has become more firmly and deeply impressed on our mind, and, after every attempt to prove its untruth and its non-applicability as an instrument of research, and a physico-biological principle around which can be grouped, or on which can be threaded, the fragments of scientific truth as they have become available, has failed, we have been compelled to admit its adaptability to these purposes, and to take advantage of its services in enabling us to advance from position to position, and to maintain the continuity and cohesion of the course we have pursued.

Circulation, as a materio-dynamic principle, is as wide as the universe, and as all-embracing as the laws of evolution and involution—matter, energy, and mind being alike subject to its operation, and conforming to its “manners and methods” in all their manifold manifestations, while the working of the entire mechanism of nature, so far as the understanding of a fractional portion of it warrants the assumption, is alone possible on the plan from which this principle derives its title. Thus, every molecule of matter, every unit of energy, and every thought of mind, follow each other in endless procession or circulation onwards and onwards, in undeviating order and succession, one giving place to the other, to the obviation of stasis, retrogression, confusion, friction, or concussion, in the maintenance of

progression and order ; while if, peradventure, there should have arisen seeming contradictions to this mode of progression and order, a subsidiary or tangential mode of progress or circulation has been secured by the *working* of the correlated circulations, whereby the apparently lost order has been ultimately regained or restored ; and so the general progress has gone on, disturbed only by these apparent or seeming obstacles to the all-embracing operation of the *law of circulation*, proving that there exist in nature after all "wheels within wheels" and circles within circles, while there is continuous progress. The law of circulation thus implies the existence of "perpetual motion" within the universe, and, therefore, contradicts one half of the physical property or law of *inertia*, or that half of the law which does not come under the all-embracing necessity of perpetual motion within the confines of the realisable universe of matter and energy, space and time (*vide* Extract on the Law of Inertia).

When applied, as a key, to unlock some of the secrets of organic circulation within the living human and every other body, this principle affords a means whereby it can be discovered that the phenomena of life, and all that that phrase implies, are but illustrations in detail of the universality of its existence and working, and modifications of its "manners and methods"; while, as a working theory, it seems possible to apply it as successfully in elucidating the deep problems which lie at the debatable point of the *fusion* into one entity of matter and energy, and of the "thousand and one" transcendental problems which ever continue to appear immediately ahead of the pioneers of science and knowledge in all its departments. By its aid anything of value in the following pages has been evolved and, more or less, elaborated in illustration of its practical working ; and to it is due any success which has been accomplished, and any value that may resist the application of criticism, as well as the practical use of any true teaching they may contain. Thus, in its application to the elucidation of the problems of life or vitality in their unicellular and multicellular manifestations, in their textural and visceral developments, as well as in their neuro-musculo-skeletal and physiologico-psychological

varieties, it throws a clear and informative light on the simple and complex phenomena involved therein, by which their manners of evolution and working can be more exactly appreciated than is possible on any other lines of research with which we are familiar.

Molecular, cellular, fibril, vascular, visceral, and neuromuscular, materio-dynamic methods of working, singly and in combination, become more evident and apparent, and to some extent the complex totality of the human organism stands out in greater relief and better perspective than can be obtained from any other point of view, until, when we arrive at that stage of its evolution where the *psychic powers* become developed, we have but to add another materio-dynamic circulation of a still higher and more subtle nature than any yet possessed or observed in virtue of mere vitality, and capable of evolution to an altogether marvellous extent beyond what characterises the merely materio-dynamic powers of the highest forms of *non-psychic life*. Moreover, we have made use of it in threading the lines of pathological manifestations throughout the tortuosities of tissue and organ where they have insinuated themselves into the regions of physiological purity and health, and have wrought out the problems of disease and death with a feeling of greater certainty than we had hitherto felt when guided by more or less haphazard lights.

Furthermore, we have felt, while thus pursuing our self-imposed explorations into the farthest material regions attainable by us, that we were touching the confines of "a region beyond" biological physics, into which we could not allow the "human disposition" to take glimpses, and these glimpses have, to some extent, been described in an appendix to what we have dealt with in biological physics and physic, under the title of metaphysics.

Biological physics will be found dealt with at considerable length under the heads of some of the material and dynamic, as well as the materio-dynamic, divisions or aspects of that very large subject, while physic follows, in less detail, and only a series of disjointed efforts have been made to bridge over the debatable area between the physical and the metaphysical, to show some of the lines

of continuity, and the bonds of union, which exist in the *united realms of natural and "revealed" truth*.

In recognising the principle of circulation as all-pervading within the area of organism generally, but more especially, for our purpose, within the human organism, we think it well to begin our application of it by a preliminary physical division of that organism into its two constituent parts of solid and fluid, or into that part which undergoes organisation, and into that other which, when the first has become organised and vascularised, circulates through it, becoming subservient to the great functions of conveying into, and out of it, the materials for its nutrition, and those which have been used up and become effete, respectively, under the titles of protoplasm and lymph.

Protoplasm and lymph may be said to represent the two essential and ultimate physical elements or principles through, and by which, life takes into itself organic form and individuality, in accordance with the laws of heredity, and the axiom: *omne vivum ex vivo*, in contradistinction to the doctrine of abiogenesis. They constitute, alike, the unicell, the multicell, and the most histologically differentiated organisms, requiring but the endowment of *transmitted* vital energy, without which their *continued existence* as organic basic units is impossible. Physico-chemically they may be imitated, but developmentally or physiologically they can scarcely be said to evince more than physical change, the great desideratum of life being wanted to initiate and continue the process of biogenesis, and the development of definite organic forms capable of persistence.

The two essential physiological elements of living, or vital, organisation, protoplasm and lymph, although absolutely distinct physical entities, cannot live apart from each other; hence, in every living body they are indissolubly joined biological elements, and the protoplasm affording stability to the lymph, and the lymph circulating throughout the protoplasm on terms of such intimacy that the result is a living organism. One universal circulation of the lymph in its various forms prevails throughout the protoplasmically composed organism marked by systemic

division into two main groups, dynamically operated by the sympathetic and the systemic nervous systems respectively—these two nervous systems *in reality constituting* the two organic elements of which the living body is composed, not only physically but dynamically: that is to say, the sympathetic nervous system innervates as well as composes the elements structural and visceral of the organic life, while the systemic nervous system, in like manner, innervates, as well as composes, the elements of the voluntary neuro-muscular life, the two jointly innervating and composing certain of the structural and visceral elements, responsive to their joint, or mutual, control in certain regions of the body. Of this universal circulation the areas principally dealt with are the nutritional, or metabolic, within the sympathetic division, and the general nervine within the systemic division consisting of what remains unaccounted for by the sympathetic, *i.e.* the neural lymph and nerve substance circulations.

In connection with the subjects of nutrition and metabolism, the basal structural organism, the cell, is dealt with in its dual developments of sympathetic nerve cell and systemic nerve cell, or neuron, respectively.

Why these areas of the universal circulation are more particularly dealt with is, that they have not been given the exhaustive attention that the other circulatory areas have received, and that if *universal circulation* is to attain to the fully understood condition of the circulation of the blood and other less widely distributed circulations, it is necessary that not a *single step, or stage, of it* should be neglected or left out.

The subjects of the neuron and neuronogenesis from their foundation position in systemic nervine nutrition and nerve energy production have also received considerable attention in several somewhat novel directions; as, for example, that every nerve cell or neuron does not receive its nutritive pabulum directly from the blood circulation, but from the matrix of this neuroglia, and, contrary to the usual teaching, that its dendritically imbibed protoplasm is excreted along its axonal process, or processes, into the sensory and motor terminal arborisations respectively, in the form of organisable material which is utilised by the

skin and muscle structures respectively, as nutritive plasma in turn.

These statements consequently require a modification of our beliefs with respect to the *power of circulation* of nerve and other fibres and their capability of conveying the elements of nutrition as well as energy.

The principle of universal circulation is intimately associated with the processes of secretion and excretion and the functions and structures of glands, consequently these subjects are largely dealt with in detail preparatory to taking up the pathological and clinical bearings of the subject.

The glands referred to particularly are the pituitary and coccygeal in their connection with the subject of cerebro-spinal lymph excretion, and the related pineal, lachrymal, nasal and salivary glands, also the parotid glands and carotids.

Moreover, this last-mentioned aspect of the subject calls for the statement of the fact that a large number of diseased conditions are found to owe their origin to interference with the principle of local and universal circulation. It is almost unnecessary to say that the data warranting these statements have been collected from all available sources and that in the course of collection thousands of individual and collected facts have been utilised, leaving behind, unutilised, uncountable stores for similar purposes which are now, to a great extent, lying idle and in danger of being buried amid the daily and yearly accumulations being added to them in all civilised countries. Indeed, it seems to us that the greatest need at the present time is the assimilation and assortment of this vast and rapidly increasing body of loosely coherent knowledge, and the deduction of the laws underlying and interpenetrating its vast bulk, ere it becomes unattainable from mere dimensions and variety.

Here we would enter a *plea* for the observance of simplicity and continuity in the syntactic advancement of science in order that every analytic fact may be utilised at once as it becomes added to the sum of knowledge, to the end that special knowledge should be at all times available for general use.

Science, as known now, has been developed slowly from chaotic notions and first principles, as the empirical gave way before the advancing tide of observation, experiment, and induction, until it has ceased to be a systematic body of knowledge and has become divided and subdivided into a congeries of sciences, more or less separate from each other, and working continuously along more or less rigidly special lines, until the principle of continuity is in danger of being forgotten, and the advantage of concerted movement lost, and the great need of simplicity in the handling of large masses of knowledge sacrificed to the requirements of increasing and strengthening specialisation.

To meet the requirements thus arising it would seem reasonable that some central means should exist that would at once be in touch with the latest advancements in special science and actuated with a keen desire to bring the whole into conformity for general purposes, whether theoretical or practical.

Thus, principles become deducible from a general survey which would remain undiscovered amid the masses of special knowledge.

Thus, for example, Harvey, from the mass of pre-existent archaic anatomical knowledge, with his own indefatigable observation and experiment, deduced the principle of the circulation of the blood, and gave to science biological an impetus which is felt at the present day and will continue a force and incentive to men of science throughout all time.

On the completion of his discovery, and the arrival of the time at which it could be presented to his contemporaries with a good hope of its acceptance, he found that there was one link which his limited powers of observation could not supply, but which he, with an inductive acumen and a scientific effort of imagination perhaps not surpassed in the annals of research, felt *must be* a definite structural provision, which, when the microscope arrived, was proved just as he surmised.

This missing link in the otherwise complete chain of blood circulation was the capillary vasculature, which united the arterioles to the venules, gave the finishing touch to his great work of discovery, and placed the

principle of circulation as an organic *modus vivendi* on a platform of absolutely demonstrable truth.

A somewhat similar dilemma befell him at an earlier stage of his investigations when brought face to face with the linking of the pulmonary and general blood circulation and their relationship to the phenomena of a unal or undivided circulation, under the control and by the divisional operation of the powers resident within the four chambers of the heart.

In solving this problem his methods and efforts met with entire success, subsequent discovery in this field having but more firmly established his title to full confidence and respect.

Since the great principle of circulation has had time to work out under the constantly increasing band of anatomical and physiological discoverers, and practical workers in the domains of related science, it cannot be gainsaid that great advances have been obvious throughout the whole domain of biological science, and that circulation after circulation has been added to the proved realities of the human organism, giving it the appearance of a combined system of circulations, the one hanging on and united to the other with the completeness of a transcendental continuity and oneness.

When examining this collection of circulations with a view, so far as we could, to attempt the appreciation of the *tout ensemble* of the circulatory chain, we have been struck with the existence of missing links, such as this which exists between the circulation of the blood proper and the related hæmal lymphatic circulation.

Within this area occur a series of circulations culminating in the assimilative, nutritional, or metabolic, which has not by any means been fully explored, and which therefore still calls for effort to place it on the level which has been so long characteristic of the other areas of the great subject.

On asking the following questions—How does the blood reach the lymphatic vasculature, and what circulatory experiences does that portion of it which becomes lymph undergo, previous to its entering that vasculature? we shall attempt an answer to the latter question first, in

order that an answer may more readily and completely be obtainable to the former.

What circulatory experiences does that portion of the blood which reaches the lymphatic vasculature pass through in becoming the specific fluid called lymph? is the question to be dealt with. We do not concern ourselves with the present views held on the subject more than that we shall endeavour to take advantage of all their teaching in order to keep ourselves in harmony with the trend and spirit of research. The alimentary circulation having ended in the blood circulation, and the blood circulation having conveyed to its capillary vasculature the nutrition-laden blood, what next takes place?

The red blood corpuscles after undergoing changes, especially of a chemico-physical order, pursue their course back to the heart for pulmonary aëration and renewal, while the white pursue a still somewhat debatable course, some, it may be, accompanying the red on their return to the heart, and some escaping through the inter-spaces of the lining endothelial cells, as "wandering cells" appearing amid the tissue elements as leucocytes, phagocytes, and others of "that ilk."

Meantime the proper nutritive elements floated in the *liquor sanguinis* are taken up by the endothelial cell osmosis, and passed as plasma into the bodies and nuclei of the cells composing the capillary lining, whence they are conveyed by the endothelial cell processes to neighbouring deeper cells, and layers of cells, and tissue elements proper, these cell processes being patent to the flow and permeable to the conveyance of physiologically prepared fluids, once more evidencing the principle of circulation as the all-pervading method of organic conveyance.

It is impossible to conceive the conveyance from the blood to the tissues of the elements of nutrition, or metabolism, on any other lines than those of continuity of lumina of circulatory ways, and thus we are warranted in inferring that the lining capillary cells take up through their walls into their bodies the nutritive plasma designed to meet the metabolic requirements of their individual organisms, and pass on what remains unused by their processes, and what is required for the nourishment of

the cells beyond, whose position in relation to immediate contact with the blood is prevented by distance, and therefore whose supplies have to be conveyed to them vicariously—thus every cell, contiguous and related, near and more distant, is supported by blood plasma, making its selection therefrom, and passes out of itself, or excretes, into the surrounding lymph spaces what it is incapable of utilising, when it becomes added to the hæmal lymph, and is re-gathered by the vasculature of that fluid to the heart.

In the central stage of this circulation, when the metabolic phenomena of integration are taking place, and the process of integration is ensuing within the cell and its connecting processes, or filaments, the circulatory process is reduced to atomic proportions throughout these textures, one atom following another in endless procession, the period or stage thus represented constituting the innermost and final distributive arrangement of the bioplasm, during which it may be said to have become, and to be absolutely alive, all the preceding stages of its circulation having added more and more vitality to it, while all succeeding stages of its circulation are in inverse manner engaged in taking vitality from it.

In this we perceive the principle of circulation to be still equally effective, and in this most cryptic central region joining the circulation of the blood to the lymphatic circulation and effecting the whole phenomena of nutrition, metabolism, and katabolism, those processes requiring the existence of histological patency and porosity, sufficiently minute and effective to allow of circulation in the atom as the great circulatory channels allow of circulation in the mass.

This manner of circulation, as we elsewhere contend, is absolutely prohibitive of stasis, regurgitation, and sepsis, and secures the existence of physiological hygiene in which the condition known as health can be effectively and continuously maintained devoid of auto-toxis.

Needless to say, all this is necessarily incapable of demonstration by any device yet known to research, and that its acceptance requires the use of a scientific faith at least as strong as was possessed by Harvey, in regard to

existence of a series of channels uniting the arterioles and venules into one united whole. It, moreover, may yet be possible to show experimentally the truth of the induction and its applicability to the pathological and therapeutical bearings of the subject.

Again, circulation within the metabolic area on these lines lays the protoplasmic elements open to the chemico-physiological forces of organic analysis and synthesis, so that waste and unemployed materials are being continually moved on, or removed, to secure the existence of an unencumbered structural condition in which physiological health can be maintained amid the fluctuations in food supply and the altering conditions of the body as to the exercise of everyday life and existence. Another great missing link in the chain of human (and higher animal) circulations is the cerebro-spinal fluid circulation, which is co-extensive and conterminous with the systemic nervous system, afferent and efferent, and which performs a function in the organism of innervation of an importance only comparable to that of the circulation of the blood in the general economy and of an absolutely specific character.

With this circulation, moreover, is associated a series of what for the want of a better term we must describe as neuronal circulations due to absorption or secretion by the nerve cells from the matrix of the neuroglia of neural pabulum, and its excretion, or growth, along the afferent and efferent nervatures respectively, into the substance of the skin, on the one hand, and the substance of the voluntary muscles, on the other.

These missing links in the chain of the general, or pan-circulation will be found elsewhere in these extracts dealt with in detail, and recognised on the afferent, or sensory, side of the nervous system as *terminal or outfall*, and on the efferent, or motor, side as *linked up again* to the circulation of the blood.

We have proved to our own satisfaction the truth of these views from both the theoretical and practical sides, and are now firmly convinced that their practical application to the subjects of diagnosis and treatment of disease it would be difficult to exaggerate, or unduly appraise.

It will be observed that the neural and neuronal circulations are only indirectly continuous with the blood circulation, inasmuch as they are separated from the blood circulation by an intervening matrix of neuroglial substance in which the nerve cells are originally laid down, from which they grow and interpenetrate the related so-called non-nervous structures, and from which they continue to maintain themselves and to exist as a great nervous system, both materially and dynamically, circulating alike and simultaneously the material and energy necessary to nourish and innervate the neuro-musculo-skeletal parts of the entire organism.

The original disposition of the blastodermic layers lays the embryonic foundation for the growth and differentiation of the future systemic, or central, nervous system and the growth of one system within another, with all that is implied in such transcendental structural arrangements of individual and united material and functional results and high evolutionary developments.

We are well aware that if these views be found tenable an alteration of our foundation neurological doctrine will become necessary, but, at the same time, hopeful that this may be effected without, to any serious extent, involving the disposition of the doctrinal substructure and superstructure which have been so admirably reared on it; moreover, we are confident that the whole fabric must be soundly constructed if it is meant to stand the increasing strain of fresh accumulations of knowledge and yield the practical results which it is entitled to afford to the pure scientist, the physician, and the surgeon.

The simplicity of working of the principle of circulation throughout the entire confines of the body becomes more and more obvious the further it is followed, until, becoming dimly cognisant of its universality as an instrument in development and evolution, we are compelled to give it a place second to none in the economy of vital operations and life.

The continuity of its working and the union of its various parts in the great chain of circulatory movements give it an ideal place in the economy of development, growth, and repair of organic structure, whether viewed

in regard to particular tissues, or organs, or the entire organism.

Thus we are convinced that the cause of the advancement of science generally and the great human desideratum, the application of that advancement to the needs of the suffering, will be stimulated and made subservient to the wants of mankind.

As the discovery of the circulation of the blood was the Open Sesame of the scientific anatomist, so it still provides a key whereby can be opened gateways into the byepaths of anatomical and physiological research, which have but to be entered to reveal the great fact that our knowledge, however advanced, is still very finite, and that there still lies ahead much that is unexplored, but which may be made more approachable and accessible along the lines of simplicity and continuity.

Every new, or fresh, discovery, moreover, reveals the fact that nature's ways and methods are universally simple and direct, and that they are absolutely continuous in their operation and consistent in their results.

EXTRACT I. A.

ON THE PRIMARY DIVISION OF THE PHYSICAL, OR ORGANIC, ELEMENTS OF THE LIVING BODY INTO PROTOPLASM, OR BIOPLASM, AND LYMPH.

Protoplasm, or Bioplasm, Lymph, and Blood.

PROTOPLASM, or bioplasm, is the physiological constituent or element through, and by which, all vital or organic material formative phenomena are effected, but the elements of which it is composed, although mechanically mixed in even definite physiological and chemical proportions, are incapable of producing life, hence a *vital* process of "admixture" or "union," under materio-dynamic conditions determined by pre-existent "biological possession," is *essential* to their manifestation of "living" phenomena, or *life*.

Protoplasm thus determined, and insured by descent, the exercise of its distinctive powers on properly prepared raw material, can convert that material into what it requires for its continued existence as a living unit or part of an organised body.

Protoplasm is the plastic or solid material out of which all living organisms, vegetable and animal, are made or evolved, and from which all the parts, organs, and viscera are constructed. It is, therefore, a substance sharply separable from the fluid or lymph, hæmal and neural, as well as the *liquor sanguinis*, and the many other more local and definite fluids to be met with throughout the body generally. It is the material, in fact, of which the living body, as a moving independent organism, is made

up, and in the interstices of which lodge the contained lymph and lymphoid fluids, or it is the decidedly solid material which imparts to the human and other bodies that character of enduringness and individuality which gives them their living generic features.

Its chemical and physiological characteristics are to some extent absolutely definite, while its power to assume whatever degree of consistence is necessary for specific purposes is unbounded, or limited only by the organic requirements of the particular organism. Every feature, organ, and histological development marks its power of adaptation, and the universality of its use in every local variety of circumstance, temporary and permanent, which arises during developmental and evolutionary progress; while the process of nutrition but marks the everyday work which it is accomplishing in the economy of growth and decay, of substitution of new for old, and of the maintenance of tissue integrity and systemic health. All the tissue elements are thus the result of the disposition of protoplasm on definite formative lines, during the long developmental progress of embryonal, fœtal, infantile, adolescent, and senile life, and each stage of that life is marked by a departure from the other, in obedience to the effects of environment on the details of its incidence, and the intensity of its local and general involvement of these tissue elements. While these departures are determined by unfailing law, when the conditions of life are absolutely perfect, and manifest themselves in regular and unfailing order in consequence, it is equally certain that any departure from these conditions must be followed by a departure from that order, in proportion to the amount of the disturbing causes and the directions in which they operate.

The protoplasmic elements of all tissues are surrounded and inter-penetrated by a fluid medium, different in chemical composition from them, and wanting in the property of life, but nevertheless essential for the manifestation of vital properties on the part of the protoplasmic elements contained therein, and necessary for the passage of dynamic influence from cell to cell, from tissue to tissue, and from the external world to the sentient structures and

vehicular agencies of the central nervous system, or sensorium, and sympathetic nervous system alike. This fluid begins to be apparent on the formation of the chyle, and continues to be elaborated, taken from, and added to, as the elements of nutrition are elaborated, metabolised, katabolised, and removed from the system as altogether effete, noxious, and beyond the reach of further nutritive service. Throughout all the modifications undergone by this fluid, or lymph, a sequence of changes takes place, determined by the exigencies of nutrition, with the associated and necessitated processes of secretion and excretion, and carried out in normal health with unerring chemico-physiological precision, complete systemic hygiene, and non-morbid results.

This fluid, therefore, circulates within and without the permanent organised protoplasmic elements and structures by virtue of inter-spaces, canals, and vessels, sometimes cystic chambers, for passive collection, being provided besides, and affords a solid medium in which many of the chemico-physiological reactions of nutrition take place. Moreover, it is not only a solvent medium, but a *mechanical washing agency*, in which the katabolic residuum of tissue waste is detached and removed and finally floated out of the system, and a great antiseptic fluid, in which the spores and developed organisms of microbic agencies are effectually dealt with by natural hygiene under the control of the *vis medicatrix naturæ*, and disease thereby averted.

We thus see in the constant and comparatively large proportion of chloride of sodium universally present in lymph and lymphoid fluids that more than accident determines the circumstance, and that it is, in fact, none other than a great natural provision for the maintenance of structural sweetness and systemic non-autotoxis, whereby the thousand and one noxious agencies entering it are dissolved, neutralised, or fixed, in non-katodynamic order, suitable for safe lodgment in, or conveyance out of, the system.

The elements of protoplasm are selected from the raw materials of the food, licked into organic shape by the formative vital energies of the various structural elements

of the body, in obedience to the developmental requirements of its various tissues, organs, and members, and maintained in life by the play of vital energy along various lines, mechanical, chemical, physiological, and what, for lack of a better term, we must still denominate specific, *sui generis*, or *purely vital*.

Each histological element of the body has for its foundation constituent protoplasm, and selects for its specific formative necessities whatever else it requires from the lymph, the *liquor sanguinis*, or other lymphoid fluid with which it is surrounded and inter-penetrated, its nutrition being thus effected from the fluids circulating throughout its substance, and carried there by the omnipresent circulation, alimentary, sanguineous, and lymphoid.

The blood, as known to physiologists, may be roughly divided into two distinct elements, viz. the *liquor sanguinis* and the corpuscles, the latter being divisible into red and white, the former, the *liquor sanguinis*, being composed, to a large extent, of the amorphous organic constituents of protoplasm, and is principally the result of immediate gastro-enteric absorption and direct transmission into the blood vasculature of the stomach and intestines, while the corpuscular elements, being mainly the products of glandular arrangement and organisation, are the result of intestinal digestive activity on the chyme, prepared in the stomach and passed in ordered array through its pyloric orifice, to be admixed with the intestinal juices and the secretions of the great abdominal viscera, and thereby rendered capable of absorption by the villi of the intestinal mucosa, and circulation through the chyloferous vessels and glands into the blood currents.

No doubt the physiological operations of the corpuscular organisation and vitalisation of the chyle lay the sanguineous foundation on which are ultimately reared the whole anatomical structure of life, and there is little doubt that the inverse process of devitalisation begins at the high-water mark of absolutely complete or perfect tissue incorporation, or metabolism, or at the acme of trophic change, where the last atomic act of integration yields to the first atomic act of disintegration, the process of integration representing the *dynamic* reign of vital phenomena,

and the process of disintegration the *adynamic* reign of vital phenomena, the two balancing each other in exact proportion so long as the condition of perfect health is maintained.

The meso- and hypo-blastic areas may be regarded as altogether actuated or innervated by sympathetic nerve influence, and consequently the protoplasmic formative and nutritive phenomena displayed in those areas may be said to be altogether effected by sympathetic agency, while the epiblastic area may be regarded as dynamically actuated or innervated by the conjoined influence of both the sympathetic and the systemic nervous systems, the metabolism of the tissues of each being effected entirely by nerve agency, material as well as dynamic. Apart from this compound, or materio-dynamic nerve agency, no life worth the name can be displayed.

EXTRACT I. B.

ON THE PRIMARY DIVISION OF THE CONSTITUENTS OF THE LIVING BODY—(*Continued*).

Lymph and Lymphoid Fluids.

THAT the term lymph is of very frequent occurrence in the literature of the sciences, constituting the foundation on which practical medicine, surgery, and obstetrics rest, is at once apparent to the most elementary reader, and that it is in continual use by the initiated in the practice of one and all departments of the medical profession is a matter of everyday knowledge and experience.

Lymph may, therefore, be regarded as a fluid of constant occurrence in the scientific and practical experience of all in any way concerned with the study and application of such subjects to the daily wants of men and animals, and as a subject many-sided in the range of its practical bearings on the application of preventive, curative, and ameliorative means and principles. Its earliest appearance as a formed, organic fluid, we may take it, is in the form of chyle. After, or when it has been thus far elaborated, and, we may assume, partially vitalised, by the gastric, and subsequently, as chyle, by the intestinal, mucosa, and the mesenteric glands, it is prepared for physical admixture and chemico-physiological union with the blood proper for further organisation and vitalisation. At this stage it becomes, from that admixture and union and its subsequent subjection to pulmonary aëration, the vehicle as well as the material of the nutritive plasma of the arterial blood either as its *liquor sanguinis*, which is the typical lymphoid fluid, co-extensive with the blood circulation, or

as a fluid constituent part of its corpuscular element. After osmotic departure from the blood vasculature, it enters the matrix of the disintegrating and vacuolated tissues to become assimilated by these tissue elements so far as their wants require, its unselected or unused residuum passing on in rear of, or blending with, the released or worn-out chemico-physiological constituents of those tissues, to find localised re-admission into the blood with the constituents of the thoracic duct, as the *lymph proper*. The lymph proper, or hæmal lymph, after occupying every tissue space and inter-space of the extra-vascular regions of the structures and organs of the body generally, apart from those of the systemic nervous system, is collected from these spaces and inter-spaces by the lymphatic vasculature proper, passed through lymphatic glands, where it is re-elaborated and, ultimately, returned into the blood for further use in the economy, or for elimination as effete and noxious excretion. Besides the hæmal lymph, which is entirely concerned in processes connected with the economy and phenomena of hæmogenesis and sympathetic nutrition, or metabolism, another form of lymph is elaborated from the blood circulation, where and when it deposits the glial elements of the neuroglia amid the fibro-cellular basis, or matrix, of that structure, and where and when, in depositing that neuro-basal substance, it releases a greater or lesser proportion of its *liquor sanguinis* to become the neural lymph or cerebro-spinal fluid. The functional rôle of this lymph, or fluid, being elsewhere treated in some detail, we content ourselves here with merely bespeaking a continued remembrance of its clinical bearings in all diseased conditions involving the systemic nervous system and those organs and structures related in any way to it by continuity of histological development and evolution as well as innervation. Lymph thus, from its ubiquity, becomes the fluid in which and through which all the vital and organic activities of the body are conducted—in which respect it may be compared with oxygen in the universal chemical processes of metabolism, or with the sympathetic nervature in its relation to the continuous or never-ending propagation and maintenance of life and life forms in all their phases and varieties.

Lymph being thus a general term for the fluid basis of all the organic fluids, primary and secondary, original and derived, circulating within the body, from the elaborated chyme, and chyle, succeeding the digestive processes of the alimentary canal, to the excretory fluids proper, and the effete products of organic waste, as they are floated out of the body, is applicable, as a descriptive appellation, with truth to all forms of hæmal, as well as neural, fluids, and, therefore, that it constitutes a bond of union or continuity between all the circulatory disposals and organic processes involved in development, growth and decay, integration, disintegration, life and death of tissue, organ, and organism. The aqueous or fluid portion of the ingesta thus becomes the basis of the lymph and lymphoid fluids, and the medium in which the solid portion of them is dissolved and held in solution and suspension preparatory to circulatory disposal to the various tissues requiring nutrition. Thus loaded, it may be said to carry the nutritive elements to the tissues and to deliver them piecemeal as the nutritive necessities of these tissues require, in atomic, molecular, or larger proportions to meet their various wants, leaving them where required ; and then, taking up the used-up and effete materials which functional activity has discharged, and whose removal is essential to maintain the condition of physiological purity and health, it delivers them into the lymphatic vasculature, to be further dealt with by it before being returned into the blood stream.

Thus alone is it possible for the hygienic circulation of nutritive pabulum to be effected, and the work of material change and exchange to be accomplished within the matrix of the various textures of which the human and higher animal bodies are composed, and thus alone is it possible for the *vis medicatrix naturæ* to be an effective agency in each such economy. Lymph thus becomes the fluid by whose circulatory movements the nutritive materials of the ingesta are conveyed to the tissues, and the refuse materials of the egesta are conveyed from the tissues, the one process of conveyance balancing the other, and both constituting a circulatory process of conveyance of unbroken continuity throughout the thoroughfares of the body ; the intricacies of the *trophic changes* constituting

the central stage, or acme, of the metabolism of nutrition, where the currency of new pabulum is given in exchange for the currency of effete, effaced, or damaged tissue elements, in the proportion of atom for atom, and molecule for molecule, with rigorous exactitude, and to the entire satisfaction of mutual needs. All the fluids met with in the body are consequently but derivatives from this fluid, serving some special purpose, and returning to the parent source, or being excreted as no longer necessary, or, it may be, hurtful to the economy of circulation and nutrition; thus, serum in all its varieties, synovia, sweat, *sensible and insensible*, glandular excretions, and the great systemic evacuations, represent the purposive utilisation and disposal of this universally disposed fluid for systemic necessities, local and general, and for the accomplishment of the "thousand and one" vital processes occurring and recurring within the vital areas. The circulation of this fluid is effected on lines beginning with, and flowing from, ingestion, and terminating with egestion, or shedding through vascular systems proper, or by quasi-solid fibres composed of fibrils, with connecting spaces and inter-spaces, from the considerable to the atomic, where the passage of the mass and the molecule are alike provided for, the *whole* constituting a system of graduated and onwardly progressive circulation through inter-material, sponge-like space and inter-space areas, from the interior of which the tissues proper extract or receive their needed pabulum, and convert it into their proper substance by their inherent vital powers, returning it by an inverse order of procedure.

This universal system of circulation requires for its performance an uninterrupted succession of circulatory ways, from its inception to its close, hence solidarity, as it is to be met with in the matrix of organic substances, can only be relative, and we must be prepared to find that nutrition is only possible so long as these circulatory ways remain patent and pervious, to the ever onward passage of the lymph streams, in which are held in solution, or suspension, the prospective tissue elements in the *cis-nutritive* lymph, and the retrospective tissue elements in the *trans-nutritive* lymph. The existence, therefore, of impervious

fibres of absolutely solid walls of hardened tissue, as containing envelopes of secreted fluids, must be understood as expressing only halfway, tentative, or temporary truths, applicable merely as convenient expressions in a transition state of scientific belief, but lacking in present adaptability, and requiring modification to meet the use of altered and altering views and beliefs.

The maintenance of this circulation, it will at once be seen, is necessary for the accomplishment of the metabolism of every texture, and for the existence of the condition of physiological health of the organism of which they form a part. Should it, therefore, fail in any part in developed vasculature, or in atomic space, from any cause, material or dynamic, then the first step in pathogenesis will be taken, and, if followed up by continued steps in the same direction, a fully developed pathological condition, or disease, will be the inevitable result, recovery from which may occur by renewal or reversal, or death from progression or persistence of the circulatory fault.

Lymph, or lymphoid fluids, are divisible into hæmal and neural, the former in turn is composed of two varieties, viz. the pre- or cis-nutritive, and the post- or trans-nutritive, while, for all practical purposes we may regard the neural lymph as one and indivisible under the title of cerebro-spinal.

Roughly speaking, the kidneys effect the elimination of the hæmal lymph, together with the neural lymph of the systemic motor nervature, while the skin, and special neural emanations, effect the elimination, with that exception, of the neural lymph. Lymph, in short, is the fluid which occupies the inter-molecular and inter-granular spaces of organised protoplasm; therefore, its influence is essential in all developmental processes, so that from the period of unicellular life of the fecundated ovum, it never ceases to perform the offices of passively occupying *vacua*, small and great, amid the stroma of living structure, and of actively conveying the elements of nutrition to, and of carrying out of, the organism all that is no longer useful, or beneficial, in the currency of its everyday changes and exchanges. Moreover, in all the stages of embryonic life, its presence, in proportionately greater quantity, renders

the work of development, amid a matrix of nutritive or organic material, which is little more than colloidal in consistence, a work of comparative ease and precision, so to speak, as, by the quasi-mechanical ballooning of cell wall, of inter-cellular space, and of organised canal, it affords a basis of physical support, on which even the most delicate histological elements can be developmentally dealt with with the least degree of confusion, and with the greatest exactitude and safety ; while, after the conclusion of embryonic development of the various textures and organs constituting that stage of growth, it yields itself still to the growing requirements of the post-embryonic and foetal organism, by allowing the expansion and extension due to constant organic additions to take place by its gradual and measured withdrawal or retirement, and by the shrinkage and folding of its containing textures, until its proportions are reduced to a "vestige of themselves," and relegated to the nooks and corners and hidden recesses of the central cerebro-spinal, or neural and hæmogenetic organs.

Amid all the vicissitudes through which this great fluid element of the body passes it retains, in its physiological condition, the characteristics of asepticity, and the power of chemical and physiological preservativeness, on which the condition of health is so inevitably and essentially dependent.

EXTRACT I. c.

ON CEREBRO-SPINAL, OR NEURAL, AND HÆMAL LYMPH IN COMPARISON WITH EACH OTHER, AND IN THEIR MUTUAL RELATIONSHIPS.

WHILE lymph is regarded as a generic term, embracing all the varieties of that fluid found in the lymphatic vessels, the cerebro-spinal cavity, and the various "shut sacs," as they are commonly called, which are to be found throughout the body, as well as in the inter- and intra-textural spaces of the connective and more organised tissues and organs, the *liquor sanguinis* being truly lymph, may be looked upon as the source from which all lymph is originally drawn, and the great storage depot, so to speak, into which it primarily and secondarily finds its way, because into it comes the chyle, fresh from the digestive organisms, with the lymphatic fluid proper, collected by the lymphatic vascular system throughout the body, to be emptied into the great blood stream. A great exception to his rule, or manner of lymph disposal, however, must be claimed, according to our views on the subject, for the distribution and direct final elimination of a great proportion of the cerebro-spinal lymph, inasmuch as it is walled off, and kept regionally separate from the lymphatic circulation proper by its own containing spaces and vessels, with the exception of its distribution to the muscular structures, where it secondarily or finally becomes continuous with the systemic or hæmal lymphatic fluid and the lymphatic circulation proper, and where, consequently, its sometimes pathological or pathogenic condition is liable to disturb the physiological lymphatic equipoise, and to

engender disease, most especially of the muscles and all the structures in which they end, and with which they are functionally connected.

To distinguish between the lymph proper and the fluid contents of the cerebro-spinal cavity and related nerve channels, it might tend to a clearer and more exact apprehension of the physiological situation involved in the foregoing remarks, were we to adopt permanently the terms *hæmal* and *neural*, the former term applying to the lymph within the lymphatics proper, and the latter to the cerebro-spinal fluid.

Naturally, these two fluids differ somewhat in chemical composition and physiological character, in consequence of their difference in genesis, and the very different offices they subserve in the economy of nutrition and elimination—the hæmal lymph being mainly, if not entirely, engaged in the work of sanguification, nutrition, and the removal of disintegrated material from the extra- or non-systemic nervine structures, while the neural lymph has its functional rôle confined within the precincts of the cerebro-spinal nerve structures proper, with the exception of their neuro-muscular aspect.

The former, or hæmal lymph, is rich in nutritive and corpuscular, or organic, materials because of its nutritional position, while the latter, or neural, is destitute of such elements, being mostly concerned in chemico-mechanical work, or, at any rate, work of that character, together with the most important function of removing from within the inter-spaces of the systemic nervous system the disintegrated and effete materials resulting from the functional activity of that system, or, as we may express it, the “*doubly distilled*” *residuum* of the vital “tear-and-wear” of both the *hæmal* and the *neural* systems, so to speak.

These things being so, we would expect to find, and are warranted in anticipating, that the neural lymph, in virtue of the dual concentration of its effete constituents, should be circumscribed, in the extent of its intra-systemic circulation, as far as is possible, and should be walled off from the hæmal streams of lymph, and conveyed out of, or from within, the precincts of the systemic nervous system directly, and without allowing a possibility of the occur-

rence of autotoxis, which would otherwise be constantly liable to take place, as is sometimes, notwithstanding, the case at the motor terminations of the systemic nerves, and beyond. This physiological necessity we find provided for by the many inter-communicating channels and excretory organs along and through which the cerebro-spinal fluid finds its exit from the cerebro-spinal cavity.

The hæmal lymph, being largely nutritive, and, consequently, prospective in systemic value, and the neural lymph largely excretory, and, consequently, retrospective in systemic value, the former requires husbanding, the latter eliminating. Regarded from a physiological standpoint these facts must, consequently, be borne in mind, so that when the pathological and therapeutical bearings of them come up for practical consideration, they, we fondly hope, will not be found barren in affording indications for the scientific use and application of both our medical and surgical skill in the suggestion, it may be, of fresh lines of attack, in the capture of the enemy's positions, in our hand-to-hand conflicts with the powers of disease and death.

I thus behoves us at all times, whether we are regarding the cerebro-spinal lymph from a physiological or a pathological point of view, to look upon it as a fluid, the vital rôle of which is largely played out, and that, therefore, it is not designed to be re-admitted into the blood stream for redistribution throughout the system, a process to which some of it—the motor—may possibly have been already subjected; besides that, its re-admission into the hæmal vascular system constitutes an outstanding danger to be constantly guarded against, lest the lethal processes of autotoxis be initiated. While the nutritive value of the cerebro-spinal fluid may be regarded as a negligible quantity or *nil*, if re-admitted into the blood stream, and while it may be regarded as a fluid destined for elimination from the economy of nutrition, as an agent which makes for autotoxis, we must, nevertheless, regard it as still playing an important part in the functional activities of the nervous system proper, cerebral, spinal, and neural, in its mechanical action as a buffer, as an

automatic regulator of intra-cerebro-spinal tension and pressure, as well as a caloric regulator, and as an insulating agency, but more especially as affording a medium by, and through which the nerve stimuli operate both in their initiation and transmission of nervine molecular changes, or currents, its chemical composition, physiological character, and intra-spatial ubiquity, insuring an ever-available environment of the nervous system, in its entire extent, of the required conditions in, or for, the most elementary, as well as in, or for, the most complex, states, or processes, of nervine and intellectual activity.

To accomplish these varied and important offices it will be at once apparent that a certain physical consistence, as well as a certain chemical and physiological composition of nervine structure and psychological balance, described in classic phrase as *mens sana in corpore sano*, is to be maintained, and, therefore, that there is here displayed a wide field for the exercise of the constantly needful potency of mental, moral, and material hygiene. In short, into this great debatable region and peripheral "lone land" surrounding the empire and citadel of our inner life and being it is of the most vital importance that we should allow nothing wrong to enter, and that we should permit nothing wrong to remain.

The analytical tables compiled by the exponents of organic chemistry will afford a means of comparing the chemical composition of the various forms of lymph and some other fluids, which may be said to be largely, if not entirely, derived from lymph, and will show that a *common chemical basis* insures and determines a more or less common physiological character of composition, the generic differences of the various fluids being due to the addition of a *specific* or particular chemico-physiological agent, or substance, the product of a particular secretory structure, agency, or gland.

We think a casual glance at, and comparison of, the analyses of lymphoid fluids by different analysts will afford the most ample justification for the advancement of the opinions that all the fluids of the body, being of common origin, have a *comparatively similar chemical composition*, and that the chemico-physiological activities of the various

organs and textures of the body are but engaged in elaborating the distinctive varieties of a common fluid for special or specific purposes. This common fluid may be said to be typified by the *liquor sanguinis*, which is the "finished article," resulting from the processes of ingestion, digestion, sanguification, and regestion, and the vehicle for the conveyance of all nourishment to all structures, while all the other fluids found within the body are but derivatives and specialised fluids, destined for specific functional purposes, or for direct and indirect elimination.

The analysis of the cerebro-spinal fluid reveals a composition of considerable chemical complexity, as well as a destitution of organised particles, and a preponderance of what may be denominated *preservative saline* ingredients, with a seemingly *strange* and *apparently* out of place substance known as *peptone*. We emphasise "strange" and "apparently," but have we not here a *survival* of neurenteric function due to the existence of a common embryonic origin, structure, and function, dating from a period antecedent to the separation of the neurenteric canal into its two divisions, and their subsequent *almost*, but *not complete*, differentiation? The largely saline character, mainly from chloride of sodium, and composition of the fluid seem to point to a *necessary* condition of *asepsis* of the medium which is responsible for the hygienic irrigation of the extra-, inter-, and intra-neural and peri-vascular spaces of the brain and cord, and to the retention of a chemical and molecular sweetness on the part of the somewhat faintly vital and amorphous material of the neuroglial matrix; moreover, we find, as already claimed, that a *medium* is thus secured, in and through which nerve impulse moves readily and spontaneously along the designed molecular channels and nerve tracts, and that its continuity and ubiquity are essential for the uninterrupted and full working of the vast materio-dynamic machinery embraced within the confines of the nervous system, central and peripheral.

The cerebro-spinal fluid, being constantly secreted or exuded by the *pia mater* and associated choroid plexuses, is distributed along the spaces and inter-spaces of the entire

nervous system, or structures, and finally exudes or is exuded from the special exits, or from the free surfaces of the skin and membranes, mucous and serous, and into the sarco-lemmar sheaths of the muscle fibres to which it is conveyed, and thence into the systemic lymphatic circulation. A large quantity, therefore, but difficult of measurement, must be constantly escaping through the sensory and motor nerve terminals respectively, the abnormal increase or diminution of which may initiate pathological conditions of the greatest importance, the removal and disposal of which must be sought for to a large extent in a clear knowledge of the problems under discussion.

The nervous system in its entirety is inter-penetrated by and bathed in this fluid initiated by and resulting from the setting free of aqueous and organisable materials from the blood in the process of developmental integration and growth, or evolution of the embryo and fœtus from the substance of the impregnated ovum, the accumulation, or increase, of which keeps pace with the increase in size of these organisms, but fluctuates—increasing and diminishing within certain limits—according to the necessities arising from its altering and evolutionary conditions and surroundings. The presence of this fluid, which in post-natal life is recognised as the cerebro-spinal fluid or lymph, throughout the spaces and inter-spaces of the nervine structures is a vital necessity in the economy of the structures for supporting and protective purposes, as well as a chemico-physiological agent in maintaining the vitality and hygiene of the neuroglial amorphous elements. Moreover, we would once more emphasise that its presence thus throughout the universal systemic nerve elements is necessary as an indispensable accessory in all functional activity of the nervous system, whether central or peripheral. In other words, nerve impulse can only be permitted to travel within or through it in the normal and physiological condition, and nerve stimuli can only reach the stimulatable molecular nerve elements and textures through it, and, therefore, that it performs something like the function or work of the fluid in the economy of the “wet cell” electric battery. Hence are explained the

positive results and negative results, respectively, in experiments on the sensory effects of the application of odoriferous or olfactory stimuli to the Schneiderian membrane, through or in the various media of odoriferous, neutral, and saline solutions, in which experiments it is most remarkable and suggestive to find that odoriferous particles can *only be well appreciated* by the sense of smell when suspended in a solution of chloride of sodium, or some equivalent saline medium or substance. We are, therefore, we think, warranted in claiming for the cerebro-spinal fluid a very wide range of influence, active and passive, in the economy of the sensory, as well as motor, phenomena of the nervous system, besides those of performing the vitally important functions of mechanical protector and supporter, chemico-physiological preserver, and general hygienic agent, with, it is conceivable, a multitude of other allied and kindred offices of greater or less importance throughout the length and breadth both of the nervous and the so-called non-nervous systems and structures.

Cerebro-spinal lymph, being a compound of the original and the residual lymph resulting from the various organic or physiological changes through which the neural plasma has passed in its preparation for, and survival from, neuronal nutrition, is therefore, as claimed, largely or wholly effete, and requiring excretion, but while largely or wholly effete, and requiring excretion, it still performs numerous vitally important functions before and during excretion, so that it never ceases to be a most important factor in the accomplishment of physiological ends and purposes; so much so, that, without it, cerebration and nerve activity generally would be impossible, and not only paralysis, but death, be the consequence.

Systemic or hæmal lymph, with which we may compare it, performs somewhat kindred functions in the economy of sympathetically determined nutrition through its being the residual material resulting from the extra-vascular disposal of the *liquor sanguinis* and waste tissue elements within the domain of that system's physiological influence, and, therefore, composed of material much of which is still to be made available for further nutritive, and, it may

be, special hæmogenetic, purposes ere it be eliminated as altogether or wholly effete. Systemic or hæmal lymph is more or less apparent and physiologically current in the earliest stages of embryonic development, even from the unicellular primary stage, and, in fact, represents the fluid medium in which is conveyed the first metabolic or living atom to the nascent and fecundated or vitalised germ organism, as well as the continually increasing stores of nutritive plasma, which the succeeding stages of embryonic development, growth, and repair more and more call for and necessitate, until the arrival of that stage of development at which appear the earliest systemic nerve elements, when an additional or the neural lymph makes itself manifest. This latter, when fully evolved by successive stages of physiological evolution, becomes recognised throughout the completely developed systemic nervous system as the cerebro-spinal lymph or fluid.

During that stage of embryonic development when the rudiments of the future systemic nervous system are being evolved and differentiated by and from the sympathetically innervated organism, the outgrowing and infolding central nerve structures emit and finally enclose this lymph or fluid, which becomes responsible for the maintaining of the patency of the central neural canal, around which are developed the manifold nerve structures to be known as the central nervous system, consisting of brain, cord, and nerves. The developmental reason for this becomes strongly apparent when we consider that the textural consistence of the early systemic nerve elements is of the most unresisting character, and that, consequently, the provision of an internal fluid support or "cushion of rest" becomes a constructive or working necessity, and, hence, we find that a column of this fluid becomes enclosed which reaches from one end to the other of the rudimentary neural tube and vesicles after differentiation of the neurenteric canal. Besides affording a mechanical support to the growing nerve textures this fluid penetrates every vesicular protuberance, as well as nerve trunk, as they are projected or developed into the neighbouring sympathetically innervated organic structures, continuing that mechanical support and bufferage so necessary even

to the terminal expansions of the individual nerve fibres, thus securing their uninterrupted development and subsequent untrammelled functional rôle. As this fluid secures an entrance into every extra-, intra-, and inter-nervine space, so it maintains throughout life a more or less complete possession of these spaces, and only retires in obedience to anatomical requirements and hydrostatic necessities, thus continuing to perform the original functions for which it was elaborated and stored and is still so well adapted to perform, as well as that of affording a means of excretion by its many guarded exits of the effete materials shed into it by the katabolic results of nervine waste. Moreover, we see in this "maintenance of possession" of these inter-, extra-, and intra-neural spaces, that a great provision is secured for the regular supply of "ready-made" lymph to such organs as the eyes and ears, which constantly utilise a somewhat large amount, and many of the glandular structures, oral and gastric, which are constantly, or periodically, active in the economy of alimentation and other functions.

We thus perceive that the functions of the cerebro-spinal lymph range themselves into active and passive, accordingly as they are physiological or mechanical, and realise that the uninterrupted performance of these functions becomes of the greatest moment in the maintenance of a physiologically perfect state of health and the preservation of the classic condition, *mens sana in corpore sano*. Surgical technique must, therefore, include the preservation of the *natural channels of exit* of this fluid in the many procedures implicating the nervous system, and be ready to supply substitutes, if necessary, for the discharge of physiological function when that has been placed in abeyance either by disease or accident.

The distribution of the cerebro-spinal fluid at the different stages of embryonic and early foetal growth, and the different periods of adult life, undergoes a more or less continuous change and fluctuation, both in regard to relative quantity and quality; thus, on the accomplishment of the neurenteric differentiation in the earliest embryonic stages of life it is relatively large—the central nervous system then only existing as a thin, elongated vesicle, filled

by it, until the accomplishment of the neurenteric differentiation and the subsequent development of the rudimentary cranio-spinal canal, with which it is at first conterminous, the succeeding stages being characterised by a gradual shortening of the canal, as its walls undergo a thickening as the neural structures increase, during which it recedes from the tip of the rudimentary coccyx to the first or second lumbar vertebra, where it afterwards remains, leaving behind it a thecal continuation, known as the *filum terminale*, to maintain a modified structural and functional connection with the posterior orifice of the enteric canal, with which it was formerly continuous, to provide a posterior exit for this neural lymph or fluid. Great but decreasing patency continues to characterise the spaces containing the cerebro-spinal fluid, and the utmost regulated freedom is provided for its excretion at the various points of exit, until, by increasing age, consequent stiffening of textures and blockage of spaces, as well as exits, a condition of comparative stasis ensues as life advances to its close, and death follows.

EXTRACT II. A.

ON CIRCULATION GENERALLY, AS IT IS TO BE MET
WITH IN THE HUMAN BODY AND IN THE
ECONOMY OF LIFE.

CIRCULATION, regarded from an anatomical point of view, is commonly applied to the movements of the blood within its containing vessels, and is accomplished—as is described by its immortal discoverer, Harvey—by muscular agency, resident within the walls of the heart and arteries.

Circulation, however, in its widest, minutest, and physiological sense, can be seen in all parts of the body, originating from, and terminating in, the blood circulation, as well as in the glands and viscera, and on the free surfaces of the body, internal and external.

Thus, the alimentary circulation may be described as the primary or central preparatory circulation, or that by which the food, solid and liquid, is made available for the maintenance of the body, the alimentary canal being at once the disintegrating, dissolving, circulating, and absorbing medium by which the chyme and chyle reach the blood stream, where they are transmuted and transformed into blood proper.

This primary circulation is supplemented by the aërial circulation, which is effected through the breathing apparatus.

The next circulation to be mentioned in this connection is the lymphatic, a circulation concerned mainly in the process of collecting the products of tissue waste and of escaped *liquor sanguinis*, or blood plasma. These modes of circulation are concerned in the maintaining of the life

and health of the body generally, with its contained viscera and attached limbs, except the brain and systemic nervous system, whose circulation is absolutely *sui generis*.

Passing to this latter, the brain and nervous system proper, we find that another series of circulations originates here, by which the life and integrity of that system are maintained, and the waste products arising from its exercise and activity removed. Thus, the substance known as the neuroglia, to which the blood circulation conveys a matrix of neuronal nutritive material fitted for the growth and maintenance of the true nervine textures, as well as for their mechanical support, becomes the scene of the origin and formation of the various neurons composing the systemic nervous system.

Surrounding and accompanying these neurons in their axonal extensions and distribution are their neurilemmar coverings, which are meningeal continuations, separated from the nerve fibres by inter-neurilemmar lymph spaces continuous with the inter-meningeal spaces, and which establish and carry on circulation of the cerebro-spinal lymph, conterminously with the nerve-fibre economy, thus constituting a circulation which is at once protective, insulating, and excretory. This circulation constitutes the peri-neural lymph circulation, which everywhere surrounds and accompanies the nerve cells, fibres, and fibrils of the brain, cord, great nerve trunks, and terminal nerve extensions, and which is actively concerned in the production of the cutaneous excretion, or sweat, and the maintenance of a proper supply of intra-cranial and intra-spinal fluid, besides assisting to form such fluids as the olfactory, ophthalmic, otic, oroglossal, gastric, pericardial, pleural, peritoneal, and synovial. The residual products, so to speak, of cerebro-spinal and neural nutrition and activity are thus utilised for the upkeep of physiological and anatomical fluids, so far as is consistent with the maintenance of health, but in this they unfortunately also may become factors in the production of pathological processes and substances.

Osmosis and capillary attraction, together with mechanical displacement and gravitation, are mainly concerned in this form of circulation, and the proper balance of its physiological and chemical conditions must consequently

be sought for as a means of preserving health along these lines.

Circulation, as here outlined, in its neural lymph aspect will be seen to be ultimately all-pervading so far as the systemic nervous system is concerned, and its sustenance, consequently, is all-important as a factor in systemic hygiene, while its re-establishment, when in abeyance, becomes a *sine quo non* in the treatment of disease.

Besides what we have said of these great anatomical and physiological forms of circulation, we may regard it—circulation—in a still wider and more comprehensive sense, as it can be seen and studied in detail in all parts of the human body and the higher orders of the animal world, in order to possess a firmer grasp and a fuller appreciation of the great problems wrapt up in the simple hydrostatics and hydrodynamics of organised textures.

Thus, we recognise that the three principal circulations, or systems of circulation, in the human subject are connected with each other by means of what may conveniently be called subsidiary or connecting circulations, or sets of connecting inter-spaces or cells. The first, the gastro-intestinal, is connected with the second, the blood circulation, by means of the lacteals and the thoracic duct, while the second is connected with the third, or cerebro-spinal, through the vasculature of the *pia mater*, the third, or cerebro-spinal, again uniting itself respectively with the blood circulation through the motor, or efferent, nervature and the gastro-intestinal circulation through the sympathetic "*nervi communicantes*."

The cerebro-spinal lymph circulation, besides again allying itself with the other two great circulations, eliminates from the body a large quantity of effete materials resulting from neural waste, by certain excretory mechanisms, these effete materials being gathered from the whole extra-, inter-, and intra-cerebro-spinal spaces, consisting of the sub-dural and sub-arachnoid spaces, the ventricles of the brain, and central canal of the cord, with the related peri-vascular and peri-saccular spaces of the neuroglial matrix, and the whole inter-neurilemmar spaces of the systemic and related sympathetic nervatures. Such a large *vascular area*, if we may use the phrase, circulating a fluid

capable of floating the disengaged materials from the entire central and peripheral nervous system, necessitates the existence of free and ample excretory facilities for the maintenance of neural hygiene, and these we find mainly provided as follows, viz.: The olfactory tracts, bulbs, nerves, and nasal mucosa, the pituitary gland, and tonsilloglosso-pharyngeal mucosa, the *filum terminale* of the cord, with coccygeal gland, and related extra- and intra-anal exits, "modified sweat glands," ductiform exits, and rectal mucosa, together with the entire system of cutaneous sweat glands and related sympathetic neuro-lymph exits wherever existent in texture and viscus.

These great circulations, with their relating subsidiary circulations, and the many visceral and organismal circulations, are engaged in conveying plastic and fluid materials along well-defined vascular channels or inter-spaces, and comprise the circulatory procedure, supplemented by the aërial circulation, which distributes to the various textural elements of the body the plasmic materials on which they live, and which they metabolise by another series of circulations extending to the final one of atomic, or molecular, dimensions, in which the vital act of tissue integration takes place, after which, by an inverse circulatory procedure, the process of disintegration is begun, and continues until the tissue elements are again devitalised and restored to the outer world of inorganic matter by the hæmal lymph circulation and its attached excretory mechanisms, the bowel, the kidneys, the skin, and the lungs. There are thus two series of excretory organisms at work in the economy of elimination, respectively belonging to the cerebro-spinal and blood circulations, with exit orifices and mechanisms of a more or less complex and specific character, to enable them to perform their individual functions. We are thus warranted in claiming the truth of the expression: *circulatio circulationum omnia circulatio!*

Speaking generally, circulation of one kind or another must be regarded as originally *all-pervading*, and as the means by which the great processes of digestion, absorption, sanguification, assimilation, nutrition, disintegration, secretion, and excretion are rendered possible, in con-

junction with the play of vital force along well-defined lines, or those of *least resistance*, throughout all the structures. These lines or channels are composed, in many cases, of highly organised hollow structures, in the form of canals such as the alimentary, of vessels such as the arteries, veins, and capillaries, of organised tubes such as the lymphatics proper, of interstitial lymph spaces, where lymph, or fluid material, first collects through cell and fibril osmosis, and of the apparently homogeneous walls of cells, nuclei and nucleoli, which are nevertheless permeable to or by fluids under the influence of vital impulse, and in obedience to the chemico-physiological laws regulating the processes of growth and decay.

Circulation, as we have said, takes place along what may be called *the lines of least resistance*, and must be looked for along those lines only; thus, along the alimentary canal, secured by its valves and sphincters, circulation, under peristaltic compression and compulsion, is easily accomplished by the highly organised and complex machinery provided in its walls, where a series of escape tubes is laid down, by which the fluid or less consistent parts of the contents are run or drawn off, leaving only a residuum of unutilisable material to be excreted. Following these escape tubes, we notice that they converge to form a single large tube, the thoracic duct, which empties itself into the current of the blood, where its contents are whirled on through multitudinous "turnings and twistings" until they reach the structures for whose growth and repair these elaborate processes are but preparatory, and where they are disposed of according to the necessities and by the laws of the process of nutrition. Once disposed of thus, a reverse, or inverse, process, viz., that of disintegration, or waste, sets in, necessitating the provision of a set of collecting spaces and vessels, whereby the waste products, suspended in the hæmal lymph, may be collected and conveyed to the appropriate cardiac and pulmonary areas for re-oxygenation, and to the excretory organs and surfaces for elimination, in order to prevent the re-introduction into the healthy textures of materials which have now become effete, and therefore toxic. The lymphatic system of vessels here

takes its origin in the tiny lymph spaces and lacunæ (like the primal springs, trickling streams, and head-waters of the river systems of the globe) inter-penetrating the organic units of the various textures—apart from the brain and systemic nervous systems, these having a “lymphatic” system of their own. Originating in these comparatively structureless spaces and inter-spaces, the lymph streams converge and pursue their course through a system of at length highly organised vessels, in whose course is interspersed a series of valves and glands whose offices seem to consist of maintaining the flow of, and turning into the current of the blood, an “innocuous and healthy effluent” stream.

These, in short, constitute the “circulations” or “systems of circulation” distributed to the head, body, and limbs, but they do not include the “circulations” still to be found within the various viscera, or within the brain and systemic nervous system.

The brain and systemic nervous system are fed with blood from the general blood stream in a manner, to some extent, we have said, *sui generis*. Thus, the arteries are said to enter the central nervous system “naked,” surrounded by lymph-filled peri-vascular spaces, and generally unaccompanied by veins. These peri-vascular spaces are filled with lymph, or fluid, from the cerebro-spinal inter-meningeal spaces—and, consequently, by the cerebro-spinal fluid—which covers and inter-penetrates the whole cerebro-spinal structures, and which (contrary to our general teaching on the subject) we contend flows along, and between, the neurilemmar sheaths of every nerve which leaves the cranial and spinal cavities to the peripheral terminations of the sensory nerve fibrils on the one hand, and the ultimate terminations of the motor nerve fibrils in the muscles on the other.

We therefore contend that the cerebro-spinal cavity is not by any means a “shut sac,” but, on the contrary, that it is permeated by at least two openings, continuous with the sub-arachnoid and sub-dural spaces, and continuous from their exit from the cerebro-spinal cavity to their ultimate termination.

In the circulation of the blood in the brain it seems to

us that the pabulum required for the support of the various textures composing that organ is laid down from the pial capillaries within the neuroglia, and comprises a large portion of the amorphous material, or stroma, of the neuroglia; that the organic matrix of the neuroglia and the neuronal cells and fibres are sympathetic in origin, the former being mainly protecting and supporting and neuronogenetic; that they together afford the soil and seed from which the systemic nerve elements proper, or neurons, originate, grow, and prolong their axonal processes, and that the nerve cells proper grow by imbibition through their dendritic processes with attached gemmules (like a plant by its rootlets from the soil) from the surrounding neuroglial amorphous materials. What takes place in this process resembles, and may, in a sense, be described as a sort of *secondary digestion*, the gemmules of the dendritic processes selecting and preparing the required nutritive materials for their respective nerve cells, the latter doing the same for their nuclei, and these in turn for their nucleoli.

The individual cell, with its processes, dendritic and axonal, its contained nucleus and nucleolus, may, as thus described, be taken as representative of a typical neuron or a nerve unit, the multiplication and totality of which constitute the systemic nervous system. Here, therefore, comes in the necessity for the provision of an efferent system of lymph circulation which will carry the results of nerve waste and disintegration safely out of that system, and out of the system generally, and will so prevent the toxic effects likely to follow from the retention of the "doubly distilled" results of hæmoneural "wear and tear." The system of cerebro-spinal lymph circulation may, therefore, literally be said to run off "brain sweat" from and through the peri-vascular and connected peri-neural spaces into the cerebro-spinal intra- and inter-spaces, or the ventricular spaces, the central canal of the cord, and elaborated sub-arachnoid and sub-dural spaces, with the related and continued peri-neural inter-spaces which, in continuity, accompany the various cephalic and spinal nerves in their entirety to their outer extremities, cutaneous and muscular.

EXTRACT II. B.

ON THE MINUTELY PARTICULAR, OR NUTRITIONAL, AND METABOLIC CIRCULATION.

SUCCEEDING the great blood circulation proper, in the centre of which is situated the great dynamic circulatory organ, the heart, the neuro-muscular walls of which propel its life-supporting materials into every "hole and corner," "nook and cranny" of the entire body, and commencing at the great organic "watershed" is the metabolic circulation. The term "watershed," as used here, is to signify that all the preparatory or preceding stages of circulation, and all the consequent or succeeding stages of circulation are subsidiary, and only subservient to the process of nutritive circulation and metabolic selection, where the incorporation and detention of the nutritive protoplasm is relatively, but not really, an exception to the existence, even in this seemingly solid and immobile region, of the presence of circulation. Thus a "watershed" signifies the dividing line which determines what direction moisture deposited on it must take in order to reach a level, or the level of the nearest sheet of water, and ultimately the level of the sea. What here is not licked up by the wind, or vapourised by the rays of the sun, after lingering for a brief period in balanced and pellucid liquidity, or gelid plasticity, like the arrested molecules of the nutritive pabulum in the interstices of the tissue matrix, resumes, by the inexorable influence of gravitation, its onward circulation or progress, resting not until it has reached its temporary or more permanent destination, which must be determined by its

environment along the lines of least resistance. A further resemblance between these natural occurrences, thus brought together, is that the matter affected and circulating in both instances at this supreme juncture has been reduced to a molecular or atomic condition, in which state it is deposited by metabolic selection and a cool atmosphere respectively on the respective "watersheds" of living tissue, and arresting earthen elevation or mountain ridge, so to speak. In the case of the organised textures of the body generally the elements of the extravasated capillary blood plasma are taken up by the process of nutrition embodied in and appropriated by these textures, for a time remaining constituent portions of them, and again, by katabolic change, being released from organic union and permitted to resume or to pursue another but still onward course or circulation, when they are taken up by the incipient lymphatic vessels and returned again into the blood circulation. This first stage of what we may call the katabolic return or inverse circulation is thus preceded by what we would denominate the central or innermost circulation of all, or what is equivalent to a molecular, or incorporative, (if we may use the term) circulation, the rate of which must be slow or quick according to the intensity and volume of integrative or disintegrative tissue changes and vital *tissue tone*; this tissue, or incorporative, circulation being succeeded by the lymph circulation, which commences on the distal side of the organic watershed. Contemporary with the latter ensue quite a number of more limited or circumscribed subsidiary circulations, which have been interpolated by or projected from the central circulation, and which are connected with the nutritive conditions and the organic preparation of the blood material, as well as with the separation and elimination of effete materials. Each of these subsidiary, or interpolated, circulations is usually developed in and around a definite glandular organ of greater or lesser dimensions, sometimes called ductless, and hence we must infer that the functions of such organs are related to the work of sanguification, or a process of modification of the blood constituents of a specifically vital character, to suit the nutritive exigencies and neces-

sities of the various textures of the body. Included in the number of these circulations are the hepatic proper, apart from the portal, the pancreatic, the splenic, the renal, the testicular, and uterine, which modify the blood stream by the excretion from it of certain vitally active and certain residual materials, some of which are made available for certain digestive purposes and perpetuative functions, while the greater part is absolutely eliminated from the system. The splenic, the adrenal, the thymus, the thyroid, with other such but less prominent ductless glands, being merely modifying organisms developed within the blood circulatory apparatus, pass through the blood itself, modifying while not apparently extracting anything from it.

All these circulations are only concerned in the functions of organic life and the economy of nutrition, and are entirely dependent on the existence and circulation of sympathetic nervine energy through cell and fibre agency. Above and beyond these circulations the higher functions of systemic nervine circulation are provided for in the elaborate machinery of the central and peripheral systemic nervous system; here the first circulation with which we are met is the cerebro-spinal lymph circulation, a circulation conterminous with the structural area of that system, plus the prolongation into the sympathetic area of the motor lymph residuum; while the second or innermost discoverable is the great compound nervine circulation proper, which, commencing with the neuro-cellulo-fibral or neuronal developments, centrally extends to the musculo-cutaneous textures of the whole body where the circulated materials terminate in textural incorporation, and final shedding respectively, as muscle pabulum, on their motor aspect, and as epidermal exuviae, or debris, on their sensory aspect.

In this brief survey of circulation, as it is observed in the human organism, we observe that two distinct systems of circulation are evolved, or become apparent, namely, the hæmal and the neural, and that each of these circulations displays a central portion in which the phenomena of nutrition, or of structural integration and disintegration, take place, the preceding and succeeding circulations, or

circulative stages being merely vehicular, and subservient to the great function of nutrition, with its implied metabolism. The processes or phenomena of nutrition *being universally dependent on the economy of circulation*, we perceive that the necessity for the existence of *trophic centres within the systemic nervous system is lessened or negatived*, and, at the most, is based on the regulation of the vaso-motor neuro-muscular agencies by the sympathetic nervature, a system of nutritive, or trophic, innervation, which is all-powerful, and sufficient in all living organisms not possessed of a systemic nervous system, with the exception of muscular structures and the textural elements of the skin, which are dependent for their nutritive pabulum on the systemic motor and sensory nervatures respectively.

Broadly, it may be stated that the meso- and hypodermal structural elements are dependent for nutritional pabulum on circulatory media innervated by the sympathetic nervature, and that the endodermal structural elements are dependent for nutritional pabulum on the circulatory media resident in the central or systemic nervous system, which, in addition to the possession of its own nervine energy, is structurally and vitally innervated by the underlying and inter-penetrating sympathetic nervature. The sympathetic nervature thus continues to be the great, if not the sole trophic nervature, leaving the systemic nervature to innervate and control those parts of the organism to which it is histologically distributed, and whose nervature is purely systemic, or only secondarily responsive to sympathetic influence or stimulation.

The media responsible for the circulation of *nutritive materials* thus also become the media for the circulation of *vital energy*, more especially in the cryptic structural regions in which the phenomena of metabolism take place, and where the nutritive processes are wrought out amid the molecular interstices of the more or less homogeneous tissues. Metabolism and nutritive circulation in their terminal stages may, therefore, be regarded as processes of physiologico-chemical circulation where the circulation is reduced in dimensions to the proportions of an atomic procession into and out of the vitally coherent mass of

organised protoplasm known as, in this case, a human body.

In like manner we may pursue the ubiquitous process of circulation materio-dynamically into the highest regions of functional activity, or cerebration, where the process begins and ends, it may be, in a single cell, or a group of cells, or associated neurons, according to the amount of neuronal machinery at work, when, it may be, a thought or idea is produced in the rough, or perhaps elaborated and polished, and added to the mental furniture, or circulated into the outer world and made available for future currency.

Man may, therefore, be said to be really as well as metaphorically made up of circulations, of "wheels within wheels," physically and metaphysically, of matter and energy in endless motion, the exactitude of the material working, and the perfection and extent of the functional output of which place him infinitely above his nearest relations on a platform entirely *sui generis*, and where it is impossible to conceive that he has yet exhausted the series of circulations involved in his materio-dynamic "genesis" and "exodus." Yea, rather that he is, by the *positive law of inertia*, carried vitally on by circulation when his material and immaterial parts separate into, on the one hand, inorganic earth, and, on the other, into potential energy, when the ponderable, or sidereal, is left behind, and when the imponderable and immaterial by expansion and growth is compelled to circulate *ad infinitum*. Thus is illustrated once more the truth of our contention : *circulatio circulationum omnia circulatio*. Thus also is illustrated the fact that matter and force, or energy, are alike, if not in nature, at least in their subjectivity to the law of circulation, and that the two entities are mutually responsible for the phenomena of organic life as it is met with "on the face of the earth." Moreover, the inorganic and organic elements of the earth's crust are so intimately related that the line of demarcation between the two is sometimes difficult to discover, and both are in their distinctive manners and degrees amenable and alike subject to that law, and individually illustrate, so far as we can perceive, its universality. Thus, astronomically, from

the far distant sidereal regions we are made aware by ethereal circulation of the existence of apparently similar bodies to that which we now inhabit, circulating in endless order amid the realms of space, while, geologically, we discover that from the earliest periods of vital activity, or at any rate since that vital activity left its traces behind in the earthy leaves of our mother earth's history, that ceaseless circulation has characterised the matter and energy of which that earth is composed, and, geographically, we still observe its continuance, for do we not see it in the endless process of the denudation of the "everlasting hills," and the filling up and repletion of the hungry seas, the reciprocal activities of inorganic and organic matter, the endless activities of vegetable and animal life, and the world-wide conveyance by the great human family in its manifold commercial activities both of the energy and the matter which lies around it, and which they make subservient to their purposes? Above and beyond all these types and forms of circulation, however, rise the vital circulations observed in plants and animals, and away beyond these lies a vista of transcendental circulation into which the most daring imagination can only peer, but where even scientific faith bids it follow with that trust in its ultimate realisation and satisfaction which should ever characterise the earnest enquirer and searcher after truth, whether in the material and visible world, or in the immaterial and invisible; or, in other words, the temporal and eternal. To return from this metaphysical digression to a farther consideration of the manner and method of physical circulation, as observed in plant and animal life, or organic forms, we are struck with the *universality of distribution* of certain *natural* elements, such as the omnipresent *ether*, which we possess in common with all nature, and *air* and *water*, which we possess as an individual planet. The first, or ether, does not at present concern us, so we shall direct our attention to the latter two, air and water, and more especially to the last named. Water, so far as observation has reached, or analysis has revealed, is universally present in all organic matter, and may be regarded as a *sine quâ non* in the accomplishment of organic change, and the production of all physical vital

phenomena, such as nutrition, growth, and decay. Water thus is the great vehicle in and by which the necessary pabulum is conveyed to the expectant textures, the medium in which they are dissolved, or with which they are mechanically mixed and prepared for assimilation, and the agency of exchange in the metabolic arrangements concerned in interstitial or textural nutrition. We have already written of an *incorporative* circulation, as being the central circulation in the great series of circulations, or circulatory acts, displayed in the human and allied organisms, as well as in all organic forms, and have claimed for it that it is no exception to the rule that all is circulation, but that *it is, in particular*, the circulation consisting of the *molecular, or atomic, movements* of the constituent physiological and chemical elements of which the living tissues are composed. Water, therefore, must be regarded as the vehicle by which these physiological and chemical elements are conveyed for integrative purposes to the tissues undergoing disintegration, or waste, and the medium through whose agency the phenomena of metabolism are effected, and that it acts in some such way as the following, viz. : After solution in, or admixture with, water, the elements of the nutritive plasma are conveyed by the circulatory machinery to the various tissues of the organism, where, by metabolic selection, the necessary nutritive ingredients are taken from the water, detained to repair the disintegrated and cast-off, or effete, ingredients, which must necessarily have been already, or are now being, swept away by the preceding column of aqueous solvent, one molecule, or atom, replacing another in continuous succession, as the exigencies of tissue waste determine; hence is secured what we have already insisted on and endeavoured to make clear, that the incoming and fresh are not mixed with the outgoing and effete elements of metabolic change and exchange, and that the phenomenon of autotoxis is thereby averted and made impossible in health. The water, having thus yielded up to the needy tissues its consignment of nutritive or physiologico-chemical plasma, is now at liberty to take or ally itself with and carry away into the lymph spaces and channels the results of tissue waste, and to convey them to where

the process of excretion can finally deal with them, or to where the process of hæmogenesis can make them available for farther organic purposes.

As we have said, water is everywhere present, in greater or lesser proportion, throughout every tissue and organ in the body, and consequently can penetrate, with more or less ease, into the molecular interstices of every texture, however impervious or homogeneous; we must, therefore, regard it as absolutely proved, and as a physical necessity, that circulatory facilities are everywhere afforded and that circulation does actually take place *universally* within the limits of the individual organism. As water is "to the thirsty ground," so it may be said to be to the living tissue, but in increased proportion, in accordance with the intensity of the vital metabolic changes taking place within the individual tissues. Vessels, channels, or inter-spaces there must, therefore, be throughout the entire structure of a living organism, whereby the nutritive materials can be conveyed to every empty atomic space of every texture of the organism, in metabolic exchange for the worn-out, or effete, atom which, on its displacement, or release, enters what for distinction may be denominated an efferent inter-space, channel, or vessel, for final disposal, so as to obviate obstruction to the afferent atomic circulation and the occurrence of plasmic stasis, admixture, and consequent autotoxis, pathological occurrences known to proceed from certain disease factors observed in mal-assimilation and perturbed metabolism. Circulation of vitally prepared protoplasm is thus seen to characterise all physiological organic processes, and, therefore, all pathological organic processes, and to make up, in a sense, all the vital processes concerned in organic life—a realisation, therefore, of the dynamic factors operating the vast circulatory machinery involved becomes a scientific work of great proportions as well as utility. Roughly estimated in their degrees of importance in the dynamics of organic circulation, as seen in man and the higher animal kingdom, we would place foremost in importance the great central engine, the heart, the influence of which is mainly felt throughout the blood-vessels proper, but necessarily in decreasing degree to the remotest circulatory areas embraced within the organism.

Perhaps next in importance we should be entitled to place the creation of molecular and atomic *vacua*, or voids, by metabolic or katabolic displacement, due to organic work and tissue exercise, and their refillment, by the selective tissue attraction, with fresh molecules and atoms; while, following in dynamic importance as promoters of circulation, we are entitled to include pure chemical affinity, or attraction, and the not inconsiderable influence due to capillary attractive force amid the nerve-ending intricacies of fine vessels, tissue porosities, and molecular *vacua*. These dynamic agents and others, directed and maintained by vital energy, constitute the active agencies employed in the organic circulatory work of every human and high animal form in the maintenance of its life during its "allotted span"—their lapse coinciding with its death and dissolution, their balanced operation constituting health, their unbalanced, disease.

We might sum up our observations on the subject of circulation, as thus viewed, by saying that there is but *one* circulation within our bodies, and that it consists of alimentation in all its stages, sanguification, blood circulation proper, nutrition, and excretion, with the almost countless correlated subsidiary circulations involved in the phenomena of life.

In thus summing up we have omitted, for the sake of physiological continuity, to include the aërial, or gaseous, circulation, which is equally responsible, with this compound fluid circulation, for the maintenance of life, but more especially for the more chemical activities engaged within this circulation, and in the process of metabolic change and exchange of tissue elements. In the process of sanguification the pulmonary aërial circulation plays a most important part, passing in that most important and essential element of the whole array of metabolic agencies, viz. oxygen, and carrying out the redundant carbon, thus maintaining an uninterrupted process of metabolic change, and an organic atmosphere, so to speak, of a pure and non-toxic character, amid which the manifold materio-dynamic activities constituting life can be carried on in untrammelled order with the utmost physiological precision and success, and with a vitally adjusted physical and mental balance. Circulation,

we thus again see, even invades the domain of physiological or organic chemistry and determines the manner of its operations and the character of its working—once more proving the truth of the contention: *circulatio circulationum omnia circulatio*.

EXTRACT II. c.

ON CIRCULATION AS ALL-PERVADING THROUGHOUT THE HUMAN BODY.

WE have attempted, somewhat irregularly, in these "extracts" to trace and describe circulation as the all-pervading *manner of nature's procedure* in the disposition of living as well as dead matter. We have endeavoured to trace the various circulatory acts and series of vascular and inter-spatial or interstitial arrangements by which it is carried out in the animal, and more especially human, economy, and have satisfied ourselves of the truth of our introductory contention that all is circulation within the human microcosm. Matter, from its entrance into the body, is in perpetual motion until its restoration to the outer world in the form of exhalation, transpiration, exudation, excretion, and exfoliation, as gaseous, liquid, and solid effete elements, or residua, its period of *relative rest* within it being represented by the temporary individual molecular rest amid its various tissues and visceral developments, where the displacement of one molecule is followed by the replacement of another in continuous succession, procession, or circulation, along the lines of least resistance and in obedience to the operation of the physical law of impenetrability—no two substances being able to occupy the same space at the same instant of time. A succession of circulatory acts, or disposals, of a gradually increasing complexity of detail, lead up, or forward, to the final act of the molecular incorporation, or nutritive supply to the various structures of the body, of the pabulum which they respectively require, and which they respectively assimilate, and afterwards release by

an inverse process of disintegration and excretory disposal. To this series of circulatory acts, or disposals of the tissue pabulum, there comes an exception of a most remarkable and astounding character, an exception which, in fact, constitutes a new, but dependent, and higher series of circulatory acts, or disposals, and which lifts the systemic nervous system possessed animals into a higher, and distinct, class of beings, entirely removed from the vegetable, and lower animal forms, which exist solely in consequence of their possession of a sympathetic nervous system.

This exceptional system of systemic nerve circulatory acts, and disposals of nervine tissue pabulum, begins in that enormous storehouse, or emporium, of the raw material of nerve protoplasm, provided by the great sanguineous circulation within the matrix of the neuroglia, of brain, cord, and ganglia, by a process of neuronal absorption, and onward, and outward, growth of the neuronal fibres, until their final disposal within, or as, the structural elements of the skin and voluntary muscles, where the final, or terminal, acts of excretory disposal ensue.

The acceptance of these views implies, or entails, a belief in the transmissibility of nerve protoplasm, in fact, all protoplasm, along fibrillary channels, or fibro-intra-spaces, wherever situated, and hence the further belief that all fibres are not solid, but patent, porous, or pervious, some to the passage of nutritive plasma inwards, and some to the passage of effete and residual products of the processes of nutrition and tissue waste outwards, according to their position in the economy of the great or universal system of circulation which exists in every organised body. Moreover, the systemic nervous system of circulation is surrounded by an insulating and protective circulation of fluid, or lymph, which is the means, besides, of enabling it to maintain a process of continuous "ventilation," so to speak, irrigation, and scavenging, by which the great neuroglial magazine, or nervine storehouse, and neuronal textures are kept sweet and clean. This lymph, the cerebro-spinal, has been described as "a negligible quantity"; but nothing could be further from the truth, for does it not provide a buffer-age against the concussions and frictions of everyday life, a means, while physiological conditions exist, of maintaining

an external and internal medium of asepticity and a way of escape for injured and unfit storage materials, as well as the results of neuronal tear and wear, for the greatest of all the viscera, the viscus for which all other viscera exist and work, the central nervous system in all its parts. It may, therefore, be inferred from this enumeration of a *few* of its more important functions and aspects that this circulation can alone be maintained and effected by the provision of a lymph-producing, as well as a circulatory, series of mechanisms of a most complete and elaborate description, and that, therefore, any accident to, or pathological interference with, it must be attended by the most disastrous consequences.

Thus we see, very imperfectly, but sufficiently clearly for us to recognise, the necessity for regarding the great *principle of circulation*, as seen especially in the human economy, as *operative and essential in every vital process*.

EXTRACT III.

ON THE CHOROID PLEXUSES, AND *PIA MATER* GENERALLY, AS THE SECRETIVE ORGANS OF THE CEREBRO-SPINAL FLUID.

OUR attention having been for a long time given to tracing and describing the neural lymph and its circulation in, and throughout, the central and peripheral nervous system, and working out the rôle played by that circulation, in ordinary physiological conditions as well as in the genesis, progress, and results of the diseases to which that system is liable, we have often been struck with the thought that such a circulation, embracing as it does the whole neural lymph production and disposal throughout the entire areas embraced by that system, must necessarily—to use a bull—be derived from somewhere specifically, or from a proportionately large extent, or number, of secreting agencies or structures. Of these agencies we are satisfied that the principal is the general vascular mechanism of the *pia mater*, which virtually surrounds the whole central nervous textures of brain and cord, and secretes, or excretes, into the surrounding and overlying inter-spaces of that system the proper amount of fluid, when and where required. This may, speaking generally, be regarded as fully meeting the requirements of the external aspects and inter-spaces of the structures filling the cerebro-spinal cavity, and only very indirectly, and with difficulty, the central intra-spaces and cavities of these structures; therefore, it would seem to us to require supplementing by other and internal, or intra-cerebral means, to meet directly the requirements of the intra-cerebral and intra-spinal

cavities, or spaces. For this purpose, it appears to us that the only mechanisms, or organisms, existing within the central nervous system, available for the purpose, are the choroid plexuses of the two lateral, third, and fourth ventricles, which, in fact, are the only non-nervine structures within the great central cavities of the brain,

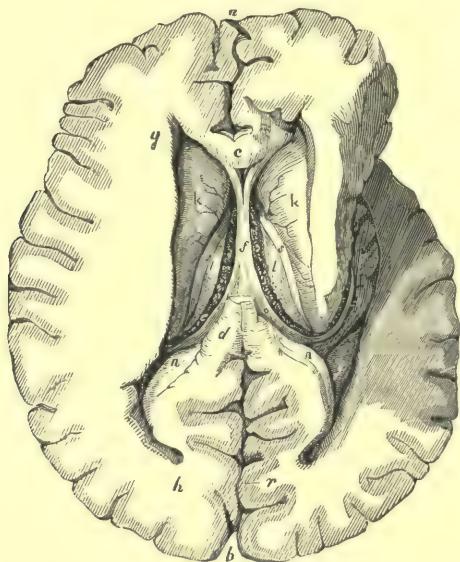


FIG. 1.—THE LATERAL VENTRICLES OPENED BY REMOVAL OF THE MIDDLE PART OF THE CORPUS CALLOSUM, AND THE DESCENDING CORNU EXPOSED ON THE RIGHT SIDE. $\frac{1}{2}$.

a, b, anterior and posterior parts of the great longitudinal fissure; *c*, section of the anterior part of the corpus callosum; *d*, posterior part of the same; *e*, the left choroid plexus; *f*, the fornix; *g*, the anterior; *h*, the posterior, and *g*, the descending cornu of the lateral ventricle; *k, k*, corpora striata; *l, l*, optic thalami; *n, n*, right and left hippocampus minor; *o*, posterior pillar of the fornix; *v*, the fimbria into which it passes; *q*, on the cornu ammonis or hippocampus major; *h*, on the medullary substance of the cerebral hemisphere; *r*, part of the grey cortical substance showing the white stria of Vicq-d'Azyr; *s*, tænia semicircularis; *j*, eminentia collateralis.

and which represent, or rather, are inflections of the *pia mater* with its vascular and connective tissues (Figs. 1 and 2). We therefore claim that the function, or at any rate the main function, of these organs or structures is that of secretion, or excretion as it might be called, into the central cavities of the brain, in which they spread out, of an internal modicum of cerebro-spinal fluid, and that a constant and physiologically suitable and graduated

supply of that fluid is thus obtained, which finds its way throughout the entire intra-spaces of the central nervous system, after which it commingles with the inter-meningeal

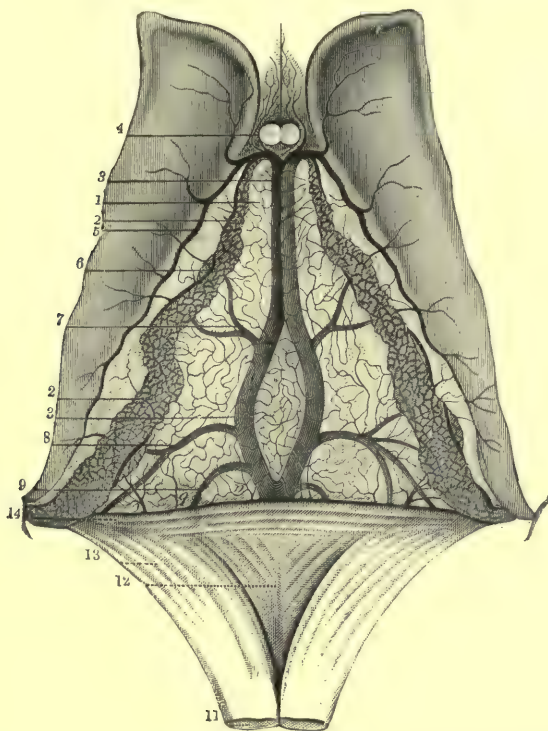


FIG. 2.—VIEW OF THE UPPER SURFACE OF THE VELUM INTERPOSITUM, CHOROID PLEXUSES, AND CORPORA STRIATA. (From Sappey after Vicq-d'Azyr.) $\frac{2}{3}$.

1, fore part of the tela choroidea or velum interpositum; 2, choroid plexus; 3, left vein of Galen partly covered by the right; 4, small veins from the front of the corpus callosum and the septum lucidum; 5, veins from the corpus striatum; 6, convoluted marginal vein of the choroid plexus; 7, vein rising from the thalamus opticus and corpus striatum; 8, vein proceeding from the inferior cornu and hippocampus major; 9, one from the posterior cornu; 10, anterior pillars of the fornix divided in front of the foramen of Monro; 11, fornix divided near its middle and turned backwards; 12, lyra; 13, the posterior pillar of the fornix; 14, the splenium of the corpus callosum.

lymph, or fluid, to form the material of the neuro-lymphatic circulation. In the performance of this function of lymphogenesis these organs become secondarily a system of elimination for securing the removal from the intra-spaces of the brain and cord whatever of neuroglial waste has found its way thither, besides affording the means

of such mechanical support and hydraulic force as are required for maintaining the patency and continuity of these intra-spaces.

Structurally the choroid plexuses are made up of inflexions, as we have said, or continuations of the *pia mater*, or more exactly of the pia-arachnoid meninges, supported by their framework of fibro-elastic connective tissue, and surrounded by inflexions of the ventricular endothelial linings—thus formed, they traverse those central intra-spaces of the brain known as the two lateral, the third, and the fourth ventricles. As regards the functions of these structures, their study may be said to have hitherto been *comparatively neglected*, their non-nervous textures apparently debarring them from *that special attention* which their situation otherwise entitles them to.

The facts that they are highly organised bodies, or textures, that they occupy a most important central position amid the most highly organised structures of the most vital organ of the body, and that they spring from, and terminate in, the blood circulating media of the brain, suggest that they *must perform* some still almost unknown functions of a vitally important nature in the economy of the great central nervous system, the discovery of which must be regarded as of consequently nothing less than the very greatest scientific interest, and physiological, pathological, and chemical importance.

The choroid plexuses being inflexions of the pia-arachnoid textures into the central cavities of the brain where no lining *pia mater* is distributed, secrete or excrete, into these cavities fluid sufficient to maintain the requisite amount of moisture therein; in other words, they distil, into the intra-spaces of the central nervous system, fluid sufficient to maintain, in conjunction with the inter-meningeal fluid, or lymph, the *equilibrium of the fluid pressure* within and without that system. A “give and take” distribution, or disposal, of the combined fluids, we take it, existing between the central cavities and the sub-arachnoid and sub-dural spaces surrounding the brain and cord, and the connected peripheral nervous system; the foramina of Majendie, and the pineal gland, among

other openings of communication, lending themselves to its accomplishment. Secretion, or excretion, being thus effected within the brain by structures organically, or histologically, continuous with its arachno-pial meninges, would more than suggest that a like function is performed by these latter, at any rate by the pial structures, and that therefore the *pia mater*, throughout its extra- and intra-cerebral and entire extent, performs the great function of keeping fully replenished the extra-, inter-, and intra-spaces of brain, cord, and nerves, as well as of supplying, in ordinary physiological conditions, the necessities of the lymph spaces of eyes, ears, and other continuous spaces.

If this be so, the *pia mater* performs the double function of conveying nourishment into, and through, the neuroglial matrix to the central nervous system, and of maintaining a fluid medium of protection and support, both within and without that system, besides maintaining mechanically the patency of its circulatory lymph paths.

These neural lymph paths, or spaces, consisting of the ventricles of the brain, the central canal of the cord, the inter-meningeal spaces surrounding both brain and cord, and the inter-neurilemmar spaces of the nerves, being, as we contend, continuous the one with the other, from the centre to the periphery of the nervous system, and being supplied from within and from without that system by a regularly formed and graduated secretion, or excretion, afford a means of escape to effete and disintegrated material, unequalled in completeness, extent, and adaptability throughout the entire extent of the excretory economy of the body, as well as a mechanical support and bufferage unique in its completeness and efficiency.

On continuing our study of the histology of the choroid plexuses we have been much struck with their adaptability to the requirements of glandular structures, and with the structural arrangement of their true glandular elements, these being situated mainly on their external aspects, the excreting cells acting in the manner of, and somewhat on the same principle as, those of the Malpighian corpuscles, or bodies, of the kidneys, the lymph, or fluid, distilling through their respective terminal textures. No doubt a like function belongs to, and is performed by, the

pia mater proper generally, more in the manner of the pleuræ, pericardium, and peritoneum.

The formation of the cerebro-spinal lymph being thus effected, and its renewal and regular supply being thus secured, by the functional activity of the *pia mater* proper and its attached choroid plexuses, let us pursue the study of it, in its course of circulatory disposal, in its important functional work within, and without, the nervous system, and in its final elimination as an excretory fluid, and bearer, of effete nervine matter and neuroglial debris.

Before doing so, and departing from the subject of the *pia mater* as a secretory medium, we should remark that its secretory rôle lies at the foundation of the genesis, growth, and entire organic integrity of the brain and nervous system. Thus, from its blood-vessels it distils the cerebro-spinal lymph from the *liquor sanguinis* of their contained blood into the lymph areas, and inter-spaces, of the entire nerve organism, while at the same time it deposits, in the matrix of the neuroglia, the nutritive pabulum for the support of that organism with its imbedded, and outgrowing, neurons, thus unburdening itself simultaneously of a double set of materials destined to perform very different functional rôles in the economy of cerebration and innervation, and nervine work generally.

EXTRACT IV.

A NEW DEPARTURE IN NEUROLOGY, OR AN ATTEMPT
AT THE SOLUTION OF SOME NEUROLOGICAL PRO-
BLEMS.

*Cerebro-spinal, or neural, lymph secretion, circulation,
and excretion.*

THE cerebro-spinal, or neural, lymph is a most important element in the economy of cerebral, spinal, and neural structure and function, serving the purposes of intracranial pressure regulator, preventer of mechanical friction and concussion, and carrier out of the nervous system of the waste and effete materials resulting from nervine "tear and wear."

In these, and many other functions, it is continually engaged, so that it is necessarily continually being secreted by the *pia mater* on the external surface of the brain and cord, and by the choroid plexuses, which are inflections of that membrane into the two lateral, the third, and the fourth ventricles of the brain, circulated through the inter-meningeal spaces, the ventricles of the brain, the central canal of the cord, and the inter-neurilemmar spaces of the whole systemic nervature, with the related sympathetic nervous system, and excreted through the olfactory nerves, the nasal mucosa, the pituitary gland, and united pharyngeoglossal mucosa, the *filamentum terminale* of the cord, the coccygeal glomerulus, and related lymph channels particularly, and by the cutaneous sweat glands generally.

It enters into every space and inter-space of brain, cord,

and nerves, separating and supporting every unit of structure, nervine and non-nervine, and keeping aseptic their histological elements, while removing every material obstruction to functional activity and every detached particle of waste texture. While thus occupying every otherwise unoccupied space without and within the whole nervous system, it is capable of yielding to every special requirement of every part of that system, like water in a sponge, and hence on the slightest increase or decrease of local, or general, pressure it escapes, or returns, along the lines of least resistance, leaving the true nervine structures free to functionate and maintain the continuity of sensory and motor innervation; thus, if "a determination of blood to the head" takes place a corresponding determination of this lymph takes place to the skin, and it may be, to one or other of the particular excretory agencies, and so equal intra-cranio-spinal pressure is maintained.

Its circulation may therefore be described as fitful rather than regular, so as to be at all times available for emergencies, however sudden or sustained; moreover, when the incidence of disease leads to an altered condition physical, chemical, or bacterial, the *vis medicatrix naturæ* uses every effort, by trying one and then another of the exits mentioned until either success, or failure, is the result.

It is necessary, however, to call attention here to the great physiological and histological fact, that another exit exists from the cerebro-spinal cavity, namely, the efferent or motor nervature, through which the lymph may escape into the proper texture of the muscles, and that when it—the lymph—is septic the occurrence must be followed by a greater or lesser degree of muscular disablement, such, for instance, as takes place in many cases of rheumatism.

When cerebro-spinal lymph excretion keeps pace with physiological requirements, and when the quality of the lymph is physiologically pure, it will follow as a physiological result that neuro-psychic health will be maintained at its highest standard, and that, other physiological conditions being equal, it will equally follow that a condition of perfect health will be the result throughout the whole organism.

The subject embraced in the above heading is a very large one, but has not hitherto been given that attention which its importance and extent entitle it to ; neither has it yet emerged from the subsidiary position of unimportance assigned to it, or permitted it, by the earlier, and even modern, observers. The intention, therefore, of the following remarks is to excite, if possible, a greater interest in the matter for its own sake, and to obtain from it the practical advantages derivable from a fuller understanding of its true meaning and import in the maintenance of innervation, and as an etiological vehicle in the incidence and spread of disease.

The cerebro-spinal fluid may be said to occupy every space and inter-space throughout the cerebro-spinal cavity not occupied by proper nervine structures or the non-nervine elements related to, or connected with, these. It, therefore, occupies a position of ubiquity co-extensive with the distribution of the systemic nervature and its related sympathetic nervous system, through the interstices of which it circulates from end to end, sometimes in cisterns, slowly, and sometimes in thinly attenuated streams, rapidly, according to the exigencies of biological hydrostatics and dynamics.

Its secretion may be regarded as the result of capillary escape of the *liquor sanguinis*, with which its chemical composition is almost identical, as the blood circulation traverses the meshes of the *pia mater* on the external surfaces of the brain and cord, or pushes its way through the cavities of the lateral third and fourth ventricles in the form of the choroid plexuses.

These latter fulfil for the central spaces of the brain and cord what the general *pia mater* fulfils for the sub-arachnoid and sub-dural spaces, while the fluids respectively secreted by them unite and form one common fluid, which circulates to and fro through certain communicating channels, or openings, namely, the foramen of Munro, the pineal gland, the aqueduct of Sylvius, the foramina of Majendie, and several lesser openings situated in the descending cornua of the lateral and the fourth ventricles respectively.

While these openings of communication afford the means by which the regulation of pressure can be effected

within, and without, the brain and cord, it follows of necessity that unless a means of escape for the fluid is also provided, a stasis and over-pressure must ensue, and this provision we find to exist in the means of peripheral circulation of the fluid and its release when, and where, required by a continuous system of enclosed, yet open, spaces, or a lymph vasculature, conterminous with the systemic nervous system in all its parts, afferent and efferent, or sensory, and motor, and sympathetic.

This circulatory and excretional provision, by which every exigency of intra-cranial and intra-spinal pressure is met by immediate re-disposal or absolute displacement of the cerebro-spinal fluid, necessitates a belief in the complete non-existence of a histological and anatomical cerebro-spinal meningeal "shut sac," inasmuch as a doubly pervious space in unbroken continuation from the sub-arachnoid and sub-dural spaces respectively accompanies every nerve, from its exit from the cerebro-spinal cavity until it finally terminates in the skin, the muscles, or the sympathetic system.

Thus, a system of continuous circulation, forwards, or backwards, according to the prevailing local and general structural necessities of intracranio-spinal pressure, can be maintained by an ordered flow, due to the operation of vital hydrostatics and dynamics along the lines of least resistance, and not against immovable obstacles, and so the safety and integrity of the great central nervous system can be maintained by a definite histological and physiological means, and not by accident. The truth of these assertions is based on such facts as that the inter-neurilemmar spaces can be penetrated to some extent by the injection of fluid from within the arachnoid membrane, but more especially, according to my clinical and pathological observations and experience, that *materies morbi*, or *viri*, chemical and material, are allowed to traverse these inter-spaces and are deposited, at their terminations in the nerve terminals, causing, it may be, a pathological manifestation there, in accordance with the nature of the virus and the character of the nerve terminal distribution in the skin or muscles involved; thus alcohol, arsenic, and certain bacteria leave a trail from the centre to the periphery of the nervous

system, along the lines of least resistance, which are here those in continuity with the inter-meningeal spaces, along the nerve trunks, fibres, and terminals.

In this way we attain a clearer view of the etiology and pathology of many diseases and morbid phenomena, such as that of metastasis, which no other means with which I am familiar will enable us to do. I, therefore, in all seriousness claim for the practical outcome of the manner and method of cerebro-spinal fluid circulation and excretion, as an aid to diagnosis and treatment, a position of great importance.

This claim would be incomplete, however, without a brief consideration of the subject of cerebro-spinal fluid excretion and the nature of the excretory mechanisms.

Secreted and circulated in the manner shortly described above, the cerebro-spinal fluid is brought into contact, more or less intimate, with every structure of the nervous system, central and peripheral, and is constantly liable to movement and displacement during its progress from its source in the *pia mater* proper and its choroid inflexions, therefore it must necessarily carry in solution, or suspension, whatever nervine material is shed into it during its intra-neural flow, and thus requires the provision of outfall facilities to enable it to dispose of these effete materials, and thereby, also, to be the means of mechanically relieving, when necessary, over intra-cranial and intra-spinal pressure.

The great central organ, the brain, must, from this point of view, be the structure discharging the greatest proportion of disintegrated and effete material into the cerebro-spinal fluid, and hence must be safeguarded to a proportionately great extent; and this is found to be the case, for here we find means of escape provided to secure drainage under all possible combinations of circulatory circumstances.

Thus, at the anterior aspect of the forebrain we have two great channels of drainage laid down from the lateral ventricles through the olfactory tracts, bulbs, nerves, and Schneiderian mucosa, with subsidiary connections with the sub-arachnoid and sub-dural spaces, and always more or less engaged in the work of physiological evacuation.

From the central, or mid-brain, a most elaborate system of drainage is effected from the third ventricle, through the

infundibulum, the pituitary gland, with which it is encapsuled, and the mucosa of the buccal cavity, which was embryonically projected upwards to, and indissolubly united with, the cerebral downward projection of the floor of the third ventricle.

A free posterior drainage is effected through the *foramen magnum* into the cerebro-spinal cavity externally, and the central canal of the cord internally, through which the residuary products of the cerebral waste and overplus fluid are allowed to gravitate, or be driven along the lines of least resistance.

The whole spaces and inter-spaces of the brain and its overlying meninges, being continuous with each other, allow the passage of cerebro-spinal fluid to circulate in every direction within, and without, the brain, and to obtain, whenever necessary, a free but guarded exit—the Pacchionian bodies providing a series of safety valves, especially along the roof of the skull, where drainage is not otherwise provided for.

The posterior extremity of the cerebro-spinal canal is, in our opinion, provided with a somewhat elaborate, but intrinsically most ideally perfect, system of drainage, effected by embryonic metamorphosis during the developmental division and differentiation of the neurenteric canal, the lumen of the canal being reduced to the dimensions of the *flum terminale* of the cord, which remains porous to the passage of cerebro-spinal fluid, and the coccygeal gland, which acts as a cystic receptacle, or lymph heart, provided with a series of “modified sweat glands” encircling more especially the postero-lateral aspect of the anus, and of ductiform outlets within the anus.

Besides these particular exits for superabundant and effete cerebro-spinal fluid, a great general system of excretion, or drainage, is provided through the sweat glands situated more or less plentifully over the entire surface of the skin, and acting individually and collectively accordingly as the necessity for the action is local, or general, the fluid reaching these glands along the inter-neurilemmar spaces of the nerve trunks, fibres, and fibrils, where the “terminal” fibrils which reach the glands pour

their surrounding cerebro-spinal fluid into their substance, to be finally excreted through their ducts on the outer surface of the skin.

When all these particular and general exits from any cause, pathological or otherwise, become unavailable, and when the cerebro-spinal fluid is driven along the remaining lines of least resistance, it is, of histological necessity, compelled to find its way along the motor nervature, local or general, according to excretional necessity, into the substance of the muscle, or muscles, there to set up, it may be, a pathological process which may lead to the production of a definite disease, such, for example, as rheumatism.

These arrangements, in short, constitute the cerebro-spinal fluid drainage system, except where it escapes into the neighbouring sympathetic nervous system, and where, if it be septic, pathogenic processes of a far-reaching character may be initiated and evolved, more especially in the way of structural and visceral disease.

It will thus, if these observations be true, be seen by those who are bold enough to take up the subject with a view to test it worth, that our estimate of it is warranted on anatomical, histological, and physiological grounds, and if so, that it is fraught with practical bearings on the progress of medicine and surgery, and is bound to become an instrument by which the incidence and evolution of many very obscure neural pathological problems may be rendered much clearer, and indications for their treatment, curative and ameliorative, be more scientifically secured.

Moreover, such traumatic, or morbid, incidents as "the spontaneous escape of cerebro-spinal fluid from the nasal" and other "passages," and the incidence of herpetic vesiculation of the skin, and eruptive cutaneous phenomena generally, find a physiological, and therefore natural and true explanation, on lines determined by anatomical and histological continuity of structure, and, what we may legitimately call, a circulatory vasculature.

EXTRACT V.

ON CEREBRO-SPINAL LYMPH CIRCULATION AND EXCRETION.

A SYSTEM of circulation having been traced throughout the whole extent of the nervous system, both central and peripheral, and the means indicated whereby the cerebro-spinal fluid, or lymph, is distributed to the most remote terminations of the individual fibrils, its secretory apparatus, or "fountain of supply," also having been pointed out, whereby it is kept constantly renewed, the reasonableness of, and the necessity for, these arrangements become more and more apparent and convincing; the study of its physiological uses, its pathological bearings and clinical applications, in our opinion, therefore, call for a share in the work of research now so active throughout the "world of medicine and surgery."

The various systems of circulation shortly alluded to, or described, in certain earlier studies are all finally subservient to this the nervine system of circulation. The circulation of the food, solid as well as liquid, of the chyle, of the blood, and of the lymph, besides the respiratory aëration, and many other minor circulatory acts performed throughout the various viscera and organs included in the human body, lead up to the final neuro-systemic circulatory acts of the supply of pabulum to the nervine structures, and the laying down of a medium of mechanical support and protection to these structures. For from the blood, we contend, are deposited in the matrix of the neuroglia, and not transferred directly to the neuronal structures, the materials on which the growth and nutrition of the

cells and fibres of the systemic nervous system are dependent, and in which they "take root" and grow—grow as plants grow from the soil in which they have been sown, or planted, and—to follow out the comparison—much in the same manner as we observe in such plants as those of the strawberry family, the primary cerebral cell representing the original unit, seed, or plant, and the



FIG. 3.—TRANSVERSE SECTION THROUGH THE BRAIN AND SKULL MADE WHILST FROZEN. (Key and Retzius.) $\frac{1}{2}$.

, corpus callosum; below its middle part the septum lucidum, and below that again the fornix; *LV*, lateral ventricle; *th*, thalamus; between the two thalami the third ventricle is seen; below the thalamus is the substantia innominata; *str*, lenticular nucleus of the corpus striatum; *c*, caudate nucleus of the same; between *th* and *str* is the internal capsule; outside *str* is the thin grey band of the claustrum, and outside this again the island of Reil at the bottom of the Sylvian fissure; *n. a.*, nucleus amygdalæ; immediately within this is the optic tract seen in section; *p*, pituitary body; *B*, body of the sphenoid bone; *sa*, subarachnoid space; *v*, villi of the arachnoid.

various ganglionic cells, developed throughout the spinal and other ganglionic centres, the secondary and semi-independent group of plants related to the parent unit. (Figs. 3, 8, 9, 10, 11).

Moreover, in the development and evolution of the nervous system within the embryo, a process of neuronal growth, somewhat akin, in its various stages, to the progress of a creeping plant, may be said to take place, which terminates only when the whole embryonic areas

have been over-spread, inter-penetrated, and organically, or texturally, arranged from centre to periphery.

The component parts of the systemic nervous system, cellular and fibrous, wherever distributed, are united into one organism under the control of the highest and higher

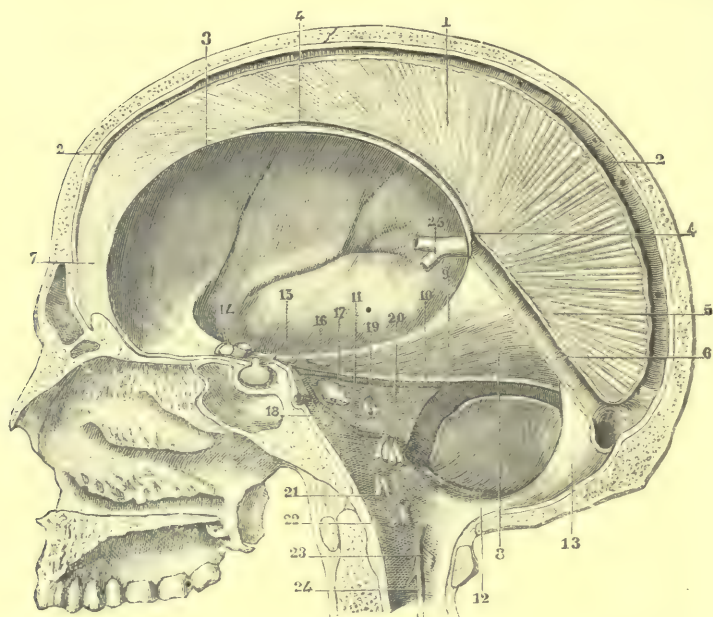


FIG. 4.—THE CRANIUM OPENED TO SHOW THE FALX OF THE CEREBRUM AND TENTORIUM OF THE CEREBELLUM, AND THE PLACES OF EXIT OF THE CRANIAL NERVES. $\frac{1}{2}$.

1, falx; 2, superior longitudinal sinus; 3, concave border of the falx; 4, inferior longitudinal sinus; 5, base of the falx; 6, straight sinus; 7, anterior part of the falx; 8, right side of the tentorium cerebelli, seen from below; 9, lateral sinus; 10, superior petrosal sinus; 11, inferior petrosal sinus; 12, posterior occipital sinus; 13, falx cerebelli; 14, 15, 16, 17, 18, second, third, fourth, fifth, and sixth cranial nerves; 19, seventh and eighth nerves; 20, ninth, tenth, and eleventh nerves; 21, twelfth nerve; 22, 23, first and second cervical nerves; 24, upper end of the ligamentum denticulatum.

centres—representing the peculiar, or central, haunt of the neuro-vital principle, or life—but are capable of exercising functions determined and directed by the lower centres for local, as distinguished from general and communal, purposes. Studied in detail, each of these parts is found to be composed of a multitudinous series of cells united to each other by processes, either of continuity, or in

contiguity, and with the different parts of the body, through axonal fibres (Fig. 4) and interpolated ganglia and ganglionic cells, the entire parts being divisible into the systemic and connected sympathetic areas—these two areas being intimately related by histological continuity, although to a great extent independent of each other in their respective functional rôles. The two systems, however, constitute a united congeries of structures of unbroken histological continuity, or intimate contiguity,

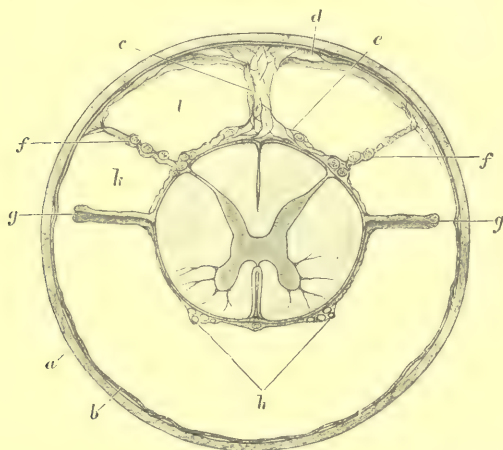


FIG. 5.—SECTION OF THE SPINAL CORD WITHIN ITS MEMBRANES (UPPER DORSAL REGION. (Key and Retzius.) Magnified.

a, dura mater; *b*, arachnoid; *c*, septum posticum; *d, e, f*, subarachnoid trabeculae, those at *f, f*, supporting bundles of a posterior nerve-root; *g*, ligamentum denticulatum; *h*, sections of bundles of an anterior nerve-root; *k, l*, subarachnoid space.

arranged within a definite series of protective and insulating media, known according to the various parts of the nervous system involved, as the meninges of the brain and cord, and the neurilemmar coverings of the nerve trunks and fibres, separated by a series of inter-spaces, continuous and conterminous with them, which are in turn filled by a fluid, commonly described as the cerebro-spinal (Fig. 5).

This fluid, the cerebro-spinal, has hitherto been mainly regarded as confined to the inter-meningeal spaces of the brain and cord and the intra-cerebro-spinal spaces (the ventricles and central canal), and has had a very limited

functional rôle assigned to it. These views we now more and more consider altogether inadequate for the following amongst other reasons, viz. because the quantity of the fluid formed is much larger than is usually supposed, being *constantly* produced by the entire secreting surfaces and vasculature of the *pia mater* covering the brain and



FIG. 6.—SECTION OF THE POSTERIOR AND LOWER PARTS OF THE BRAIN WITHIN THE SKULL, TO EXHIBIT THE SUBARACHNOID SPACE AND ITS RELATION TO THE VENTRICLES. (After Key and Retzius.)

The section was made in the frozen state, the cavities having been previously filled with injection.

1, 1', atlas vertebra; 2, odontoid process of the axis, 2', 3, third ventricle; 4, fourth ventricle; C, C, corpus callosum? C, gyrus fornicatus; C, cerebellum; t, tentorium; p, pituitary body; c, c, central canal of the cord; fM, in the cerebello-medullary part of the subarachnoid space, is close to the foramen of Majendie by which that space communicates with the fourth ventricle.

cord, besides the appendages known as the choroid plexuses (of the two lateral, the third, and the fourth ventricles), and because it fills the entire series of extra- and intra-spaces of the various structural divisions of the central (Figs. 6 and 7) and peripheral nervous system, the which, therefore, *necessitate* the formation and continual presence within the body of a *very great quantity* of cerebro-spinal fluid, and the provision of a series of safety

valves, excretory organs, or eliminatory mechanisms, which are found more or less abundantly distributed in the skin, the mucous and serous membranes, and the muscular structures, as well as viscera. Moreover, in the structures known as the olfactory nerve mechanisms, the pituitary and pineal glands, and the coccygeal glomerulus, with their associated outfall tubular arrangements and organisms, we discover structures whose conjoined functions, besides

FIG. 7.

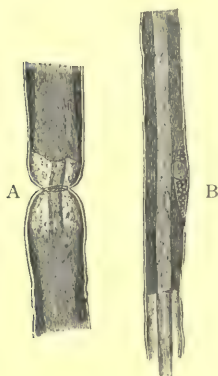


FIG. 8.



FIG. 7.—TWO PORTIONS OF MEDULLATED NERVE FIBRES, AFTER TREATMENT WITH OSMIC ACID, SHOWING THE AXIS-CYLINDER, AND THE MEDULLARY AND PRIMITIVE SHEATHS. (Key and Retzius.)

A, Node of Ranvier. B, Middle of an internode with nucleus.

c, axis-cylinder, projecting at the broken end; *g*, primitive sheath within which the medullary sheath, which is stained dark by the osmic acid, is somewhat retracted.

FIG. 8.—PART OF AN AXIS-CYLINDER, HIGHLY MAGNIFIED, SHOWING THE VARICOSE FIBRILS COMPOSING IT. (Max Schultze.)

the disposal of the more solid nerve debris, largely consist in *regulating* the incidence of intra-cranial and intra-spinal pressure, by affording a ready, albeit manifoldly guarded and regulated means of exit to the cerebro-spinal fluid. By these means and a vaso-motor controlled blood-circulation, sensitive to inward and outward circumstances and necessities, an atmosphere, so to speak, of cerebro-nervine calm and repose is maintained amid the most changing conditions of an ever-fluctuating environment. Besides the somewhat mechanical rôle here described as

belonging to the cerebro-spinal fluid, we must not forget that we shall justly attribute to it besides a most important excretory function, in that it bathes and washes the individual nerve units, or neurons, as well as the collective nervous system, collecting the worn and escaped, or disintegrating, material, and floating it out through the numerous exits provided.

FIG. 9.

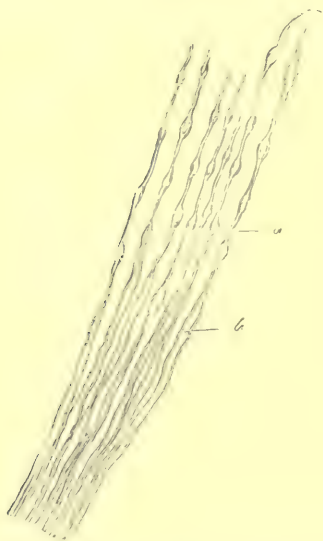


FIG. 9.—VARICOSE MEDULLATED FIBRES FROM THE ROOT OF A SPINAL NERVE. (From Valentin.)

FIG. 10.

B.

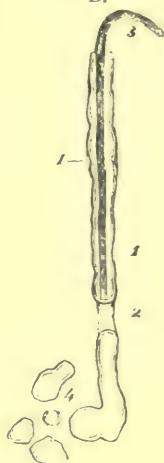


FIG. 10.—B, DIAGRAM TO SHOW THE PARTS OF A MEDULLATED FIBRE.

1, 1, *outer or primitive sheath* enclosing the doubly contoured *white substance* or *medullary sheath*; 2, a part where the white substance is interrupted, the outer sheath remaining; 3, *axis cylinder* projecting beyond the broken end of the tube; 4, part of the contents of the tube escaped.

In the performance of these excretory functions within the economy of the nervous system, we think we perceive at work a double, or composite, set of organisms, viz. a pituitary set for the removal of the more solid, and a serous set for the removal of the more fluid materials, finding an entrance into the cerebro-spinal lymph spaces. To the first of these belong the olfactory, besides the pituitary body, and it may be the coccygeal body; and to the second the pineal body, and the various sweat glands

of the skin, while to a third, we may infer, belong the sebaceous glands of the skin, as well as some of the glandular structures distributed throughout the intestinal canal and elsewhere. In the last mentioned may sometimes be included the pituitary gland and nasal mucosa, because their functions are regulated and determined by the consistency of the materials supplied to them for the



FIG. II.—RIGHT HALF OF THE BRAIN DIVIDED BY A VERTICAL ANTERO-POSTERIOR SECTION (from various sources and from nature). (Allen Thomson.) $\frac{1}{2}$.

1, 2, 3, 3a, 3b, are placed on convolutions of the cerebrum; 4, the fifth ventricle, and above it the divided corpus callosum; 5, the third ventricle; 5', pituitary body; 6, corpora quadrigemina and pineal gland; +, the fourth ventricle; 7, pons Varolii; 8, medulla oblongata; 9, cerebellum; i, the olfactory bulb; ii, the right optic nerve; iii, right third nerve.

time being. Thus we see that the olfactory mucosa during the prevalence and progress of a catarrh, sometimes discharges a fluid, sometimes a viscid material, and sometimes a compound of both.

Therefore should the physiological balance in consistency and means of exit of this fluid—the cerebro-spinal—be to any considerable extent, or for any lengthened period disturbed, it becomes self-evident that the end must be a pathological condition, characterised as to incidence, and nature, according as the disturbance

involves the liquid or more solid elements of the fluid, under either, or both, of which conditions the indications are, in a word, to obtain and maintain the "freedom of exit."

As types of the pathological conditions resulting respectively from a disturbed condition of the pituitary and serous elements of the cerebro-spinal fluid respectively, we would mention acromegaly and acute rheumatism.

EXTRACT VI.

ON NERVINE, OR NEURONIC, SECRETION, AND INTRAFIBRAL CIRCULATION OF THE WHITE, OR MEDULLARY, AND THE AXIS CYLINDER SUBSTANCES, AND ON THE STRUCTURE OF SYSTEMIC NERVE FIBRES, WITH THE "NODES OF RANVIER."

As bearing on, and dovetailing with, the subject of maintaining a proper circulation and "pressure equilibrium" within and without the nervous system in its widest aspects, a few of the ways in which excretion is secured from that system may be shortly described, in supplement of what has already been incidentally said when alluding to the details of cerebro-spinal circulation and excretion. The first in prominence, and to some extent in importance, is the nasal excretion or discharge, which is more or less constant, and abundant under ordinary circumstances, but which may, in response to the stimuli of sneezing, blowing, and rubbing of the nose, be supplemented as occasion requires (Fig. 12).

The second consists of the tonsillo-glosso-pharyngeal mucosa, and represents the local outfall, or outflow, of the pituitary gland (Fig. 15). The third may be described as the anal, or perineal, and may be said to be due to gravitation and capillary force, aided and increased by the movements of the lower extremities when in activity, and regulated by the action of the muscular texture of the coccygeal body and overlying anal musculature. While the fourth, and greatest in extent, may be denominated the general one, that is, through the peripheral endings of the nerve fibrils throughout the body, as illustrated

by ordinary transpiration and perspiration, both general and local.

In other words, the process of excretion of nerve debris would seem to us, on continuing the study of its mechanisms, to be affected through several channels in particular, and through the nerve endings, motor and sensory, in general, the particular channels being the olfactory tracts and nerves, the glosso-pharyngeal, or

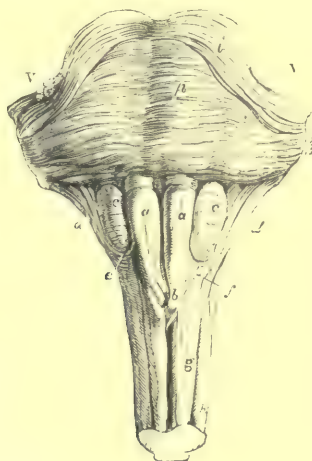


FIG. 12.—VIEW OF THE ANTERIOR SURFACE OF THE PONS VAROLII AND MEDULLA OBLONGATA, WITH A SMALL PARTICLE OF CORD ATTACHED.

a, a, pyramids; *b*, their decussation; *c, c*, olives; *d, d*, restiform bodies; *e*, external arciform fibres, curving round the lower end of the olive; *f, f*, fibres described by Solly as passing from the anterior column of the cord to the cerebellum; *g*, anterior column of the spinal cord; *h, h*, lateral column; *p*, pons Varolii; *i*, its upper fibres; *v, v*, roots of the fifth pair of nerves.

pituitary, excretory mechanism, and the coccygeal gland and associated structures, with, it may be, the axillary glands, so far as they are related to the systemic nervous system and certain cutaneous surfaces, particularly between the toes and fingers; the odoriferous qualities of the excretion in these latter regions, howsoever produced, whether from hæmal, or neural, sources, or both, pointing to high toxicity, and the consequent necessity for its immediate elimination from the system, or before it has had an opportunity of rejoining and contaminating the returning hæmal lymph streams.

The general cutaneous surface (Figs. 16, 17, 18) may be said to afford the largest area for the requirements of the economy of systemic nervine excretion. It will be observed, however, in this enumeration of eliminatory means, that apparently no provision is thereby provided for the excretory necessities of the sympathetic nervous system. This, however, we think can only be apparent, not real, because its trophic functions demand the fullest excretional facilities which can be afforded, and on the free

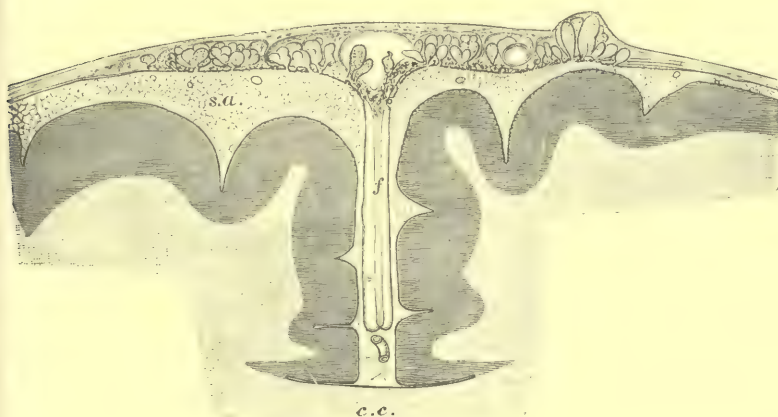


FIG. 13.—SECTION OF THE UPPER PART OF THE BRAIN AND MENINGES TO SHOW THE RELATIONS OF THE ARACHNOIDAL VILLI. (Key and Retzius.) Magnified.

c, c, corpus callosum; *f*, falx cerebri; *s.a.*, subarachnoid space, pervaded by a network of fine trabeculae; from it the fungiform villi are seen projecting into the dura mater. Some are projecting into the superior longitudinal sinus, *s*.

surfaces of the skin, and of the mucous and serous membranes lining the various cavities of the body, as well as on the various synovial surfaces of the joints and bursæ, and through the great excretory organs, the kidneys. It will thus be seen that the sensory side of the nervous system proper, and the sympathetic system, are provided with an abundant and ready means of relieving themselves of their waste products, but that the motor side of the nervous system proper is not correspondingly provided for. When, however, we consider the matter in its details we think we will be able to see that excretion even here is effected by and through the terminal nerve fibrils,

within the substance of the muscular structures to which they are distributed (Figs. 19, 20).

The neurilemmæ surrounding the motor nerve-terminal fibrils become continuous with the sarcolemmæ of the

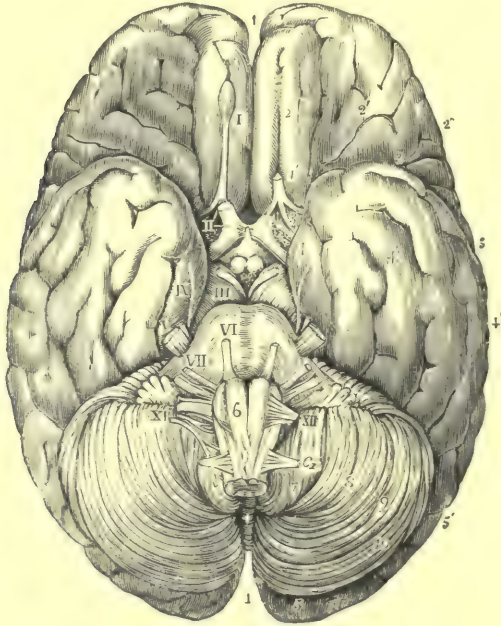


FIG. 14.—BASE OF THE BRAIN WITH THE ORIGINS OF THE CEREBRAL NERVES. (Allen Thomson.) $\frac{1}{2}$.

This figure is taken from an adult male brain which had been hardened in alcohol.

- 1, superior longitudinal fissure; 2, the olfactory tract and sulcus; 2', orbital convolutions; 2'', inferior frontal convolution; 3, 3, 3, fissure of Sylvius; 4, 4, 4, temporo-sphenoidal lobe; 5, 5', occipital lobe; 6, on the right anterior pyramid of the medulla oblongata above the decussation; 7, amygdaloid lobe of the cerebellum; 8, biventral lobe; 9, slender lobe; 10, posterior inferior lobe; +, the inferior vermiciform process; I, olfactory bulb; I', the tract divided on the left side; II, in the anterior perforated spot, marks the right optic nerve; the left has been cut short; III, on the right crus cerebri, denotes the third nerve; IV, the fourth nerve; V, the fifth; VI, on the pons Varolii, the sixth; VII, also on the pons Varolii, the facial with the auditory nerve on its outer side; XI, on the cerebellum below the flocculus, indicates the spinal accessory nerve; between it and the auditory are seen the glosso-pharyngeal and the vagus; XII, on the upper part of the left amygdaloid lobe, denotes the hypoglossal nerve; C¹, on the same, the suboccipital nerve.

various muscular fibres on which they are spread, or with which they are connected, the terminal organs, or “muscle plates” excreting into the substance of these structures their entire contents, and, consequently, their effete

materials, or such as find their way along that side of the systemic nervous system. Here the *general* lymphatic circulatory system, as distinguished from the cerebrospinal lymph circulatory system, takes up the function of removal or scavenging, of the materials so excreted, as well as of those resulting from muscular action and tear and wear, and, combining them, removes them to the great blood stream for final disposal—the lymph spaces,

FIG. 15.

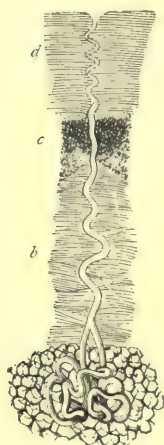


FIG. 16.

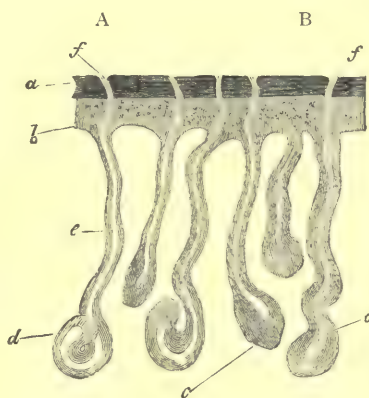


FIG. 15.—MAGNIFIED VIEW OF A SWEAT GLAND, WITH ITS DUCT. (Wagner.)

a, the gland surrounded by fat-cells; *b*, the duct passing through the corium; *c*, its continuation through the lower, and *d*, through the upper part of the epidermis.

FIG. 16.—DEVELOPING SWEAT GLANDS FROM A SEVEN MONTHS' FOETUS. Magnified 50 diameters. (Kölliker.)

a, horny layer of the epidermis; *b*, Malpighian layer; *d*, rudimentary gland; *e*, lumen of the duct, opening at *f* upon the surface of the skin.

channels, vessels, and glands of the lymphatic circulation proper, each contributing their "quota" of *conveying and sorting of the refuse material*.

The distribution of the systemic motor nerve fibres and fibrils, as well as the sympathetic motor filaments, is virtually to every muscular fibre and fibril in the body, whether striped, or unstriped, and suggests, as elsewhere stated, the thought that these motor nerve fibrils might convey to the sarcois elements of the muscular system universally, nutritious material, as well as force, or impulse,

which thought further suggests that toxicity of that supply of material would result in pathological disturbance of the muscular structures to which the nerves affected were communicated. Thus, it might be inferred that such a disease as rheumatism might, and most likely does, arise from a contaminated, or toxic, supply of neural excretion; or, as we contend, nutritive plasma, and that the pain and stiffness characterising that disease are due to the conveyance, or circulation, of a certain *materies morbi* from the nerve endings into the muscular structures involved.

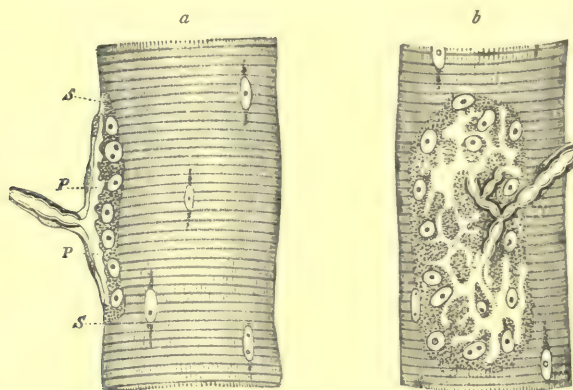


FIG. 17.—NERVE-ENDING IN MUSCULAR FIBRE OF A LIZARD (*Lacerta viridis*), ACCORDING TO KÜHNE. (Highly magnified.)

a, end-plate seen edgeways; *b*, from the surface. *s*, *s*, sarcolemma; *p*, *p*, expansion of axis-cylinder. In *b* the expansion of the axis-cylinder appears as a clear network branching from the divisions of the medullated fibre.

Rheumatism will, therefore, most likely be found to be, and we think is, a disease primarily of the nervous system, and not of the blood, the blood becoming secondarily affected through, or by the removal into it of, this toxic matter, through the agency of the lymphatics returning from the affected muscles, or by direct imbibition of the tainted material, or *materies morbi*, by the blood-vessels supplying them. But this is a digression into the pathological aspect of the subject of circulation which can be more consistently dealt with when we reach the clinico-pathological stage; we shall, therefore, resume the study of *neural circulation*, *extra-* and *intra-*. But the extra-neural circulation having already been considered in some detail

in this and previous studies, we shall first proceed to discuss the nature of what we, by a use of "scientific licence," may call the *intra-neural circulation*.

The intra-neural circulation, if circulation it can truthfully be claimed to be, is, like the extra-neural circulation, of a duplex character, and it consists of the necessarily limited movements within more or less completely closed

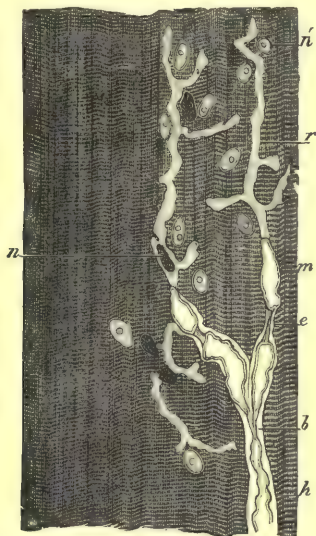


FIG. 18.—TERMINATION OF A NERVE IN A MUSCULAR FIBRE OF THE LIZARD (*Lacerta viridis*). (Ranvier.) Very highly magnified.

h, outer sheath of the nerve-fibre (sheath of Henle, according to Ranvier); *b*, bifurcation of the fibre; *e*, node; *m*, short segment beyond the node; *r*, terminal ramifications of the axis-cylinder; *n*, nuclei on the branches of the axis-cylinder; *n'*, nuclei in the granular substance of the end-plate. The granular substance lies in the intervals between the branches of the axis-cylinder; it is not seen in this figure.

vessels of plastic, or semi-fluid, substances as represented by, in the first place, the "white substance of Schwann," and, in the second place, by the substance of the "axis cylinder" (Figs. 8, 9).

The intra-neural, or axonal, circulation is necessarily, therefore, entirely different from the extra-neural circulation, inasmuch as it consists of the movement of that substance, or those substances, which may be described as truly *nervine* within the walls of the nerve cells and the lumina of the nerve fibrils, which latter are bi-tubular and may be

slow, or rapid, according to the condition of the body in relation to rest and movement, and according to the activity of the sanguineous circulation and the mental organism (Figs. 18, 19).

This circulation is molecular and capillary, and is effected by the usual forces operative under such circumstances, plus the influences due to vitality, in each of which respects it may be compared to the "ascent of the sap" and kindred movements in plant life.

The substance composing the axis cylinder of nerve fibril (Figs. 8, 11), or what we may call the true *nervine substance*, is of consistency sufficient to prevent

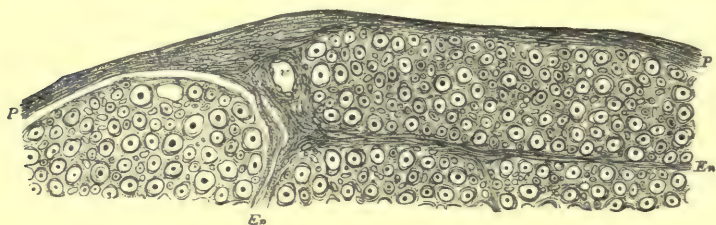


FIG. 19.—PART OF A SECTION OF ONE OF THE FUNICULI OF THE SCIATIC NERVE OF MAN. Magnified (after Key and Retzius).

P, Perineurium, consisting of a number of closely arranged lamellae. *En*, processes from the perineurium, passing into the interior of the funiculus, and becoming continuous with the endoneurium, or delicate connective tissue between the nerve-fibres. The connective tissue fibrils of the endoneurium are seen cut across as fine points, often appearing to ensheath the nerve-fibres with a circle of minute dots (fibril-sheath of Key and Retzius). Numerous nuclei of connective-tissue cells are imbedded in the endoneurium; *v*, section of a blood-vessel.

rapid movement, but is yet sufficient to allow of considerable molecular and mechanical displacement, and *hence circulation*; as, for example, when a nerve trunk is pressed upon for some time its nerve fluids, or its intra-fibrillar contents, become discontinuous to such an extent as to prevent the passage of the usual nerve force currents until their continuity is again restored, which usually requires an appreciable time. The axis cylinder, or true nervine substance, is surrounded by a coating, or containing wall, of neurokeratine, which, in turn, is overlaid by a continuous covering of the "white substance of Schwann" enclosed by its containing, or primitive, sheath, also composed of neurokeratine (see figure 8, page 73). The continuity of this insulating and protective covering, or tube, of "the white substance of Schwann," or medullary sub-

stance, is said to be interrupted by the "nodes of Ranvier" (Figs. 8, 20), but we contend that this is only apparent and not real, and that the apparent interruption is due to *the compression, but not to the complete interruption, of its continuity* exercised by those nodes, and thus, moreover, is secured the apparent *raison d'être* of this insulating protecting medium. The axis cylinder being necessarily for functional purposes, continuous from source to termination in its fully formed or normal condition within each neuron, and depending for its integrity on the completeness of its surroundings and insulating structures, we feel ourselves warranted in inferring that the "white substance of Schwann," with its containing sheath or neurilemma, is also

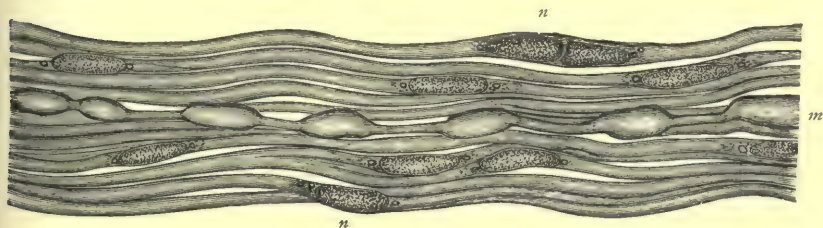


FIG. 20.—A SMALL BUNDLE OF NERVE FIBRES FROM THE SYMPATHETIC NERVE. (Key and Retzius.)

The bundle is composed of pale nerve-fibres, with the exception of the fibre *m, m*, which is enclosed here and there by a thin medullary sheath; *n, n*, nuclei of pale fibres.

continuous, although the apparent interruptions in its course caused by the occurrence of the "nodes of Ranvier" seem to militate against that view. Thus, circulation of a somewhat limited extent is possible here, and, we think, required to maintain the continuity, and hence the vitality, of this viscous, but yet fluid, substance, and we, therefore, regard it as adding one more to the far from exhausted series of human corporeal circulations.

Our reference to the "nodes of Ranvier" and our expression of dissent from the received opinion regarding their complete interruption of the continuity of the medullary or "white substance of Schwann," necessitate we think a *further* reference and, if possible, a fuller explanation of the questions involved. The "nodes of Ranvier" are histologically well-defined structures, occurring at certain, but varying, intervals, along the

course of a large portion of the peripheral nerve fibres, comprising the nerve trunks of a great proportion of the systemic nervous system, and it may be certain communicating filaments of the sympathetic system, and being thus so well defined and so widely distributed, we must suppose that they possess functions and perform a duty, or duties, static or dynamic, in the complicated economy of the nervous system. We must, consequently, proceed to assign a use, or function, to the "nodes of Ranvier," and in doing so we must observe that a tube like the containing sheath of the "white substance of Schwann," and of the axis cylinder substance, must be subjected to great strains from external pressure, as well as from the disrupting influence of bulging from within due to disturbances of the continuity of their contents, which, we may take it, are usually in a semi-fluid state. We therefore consider ourselves warranted in regarding these structures, these "nodes of Ranvier," as *circular supports* developed in, and around, the substance of the primitive membrane, or containing wall, of the "white substance of Schwann," in the manner of *strap and buckle* arrangements of their constituent material; and that it is further possible to recognise, as the agents in their production, growth, and continuation, the "nerve corpuscles" or "cells" distributed along the course of the same membrane.

If this *strengthening or supporting function* of these "nodes" be granted it is no longer a matter of surprise or wonder that a peripheral- or systemic-nerve- or trunk- is such a *resisting structure*, and that the continuity of the axis cylinders of its component fibres is so admirably maintained and ensured. The "nodes of Ranvier" must therefore rank as *adaptations of texture* to meet special emergencies of the greatest importance. But it seems to us that besides the function of *support* performed by the "nodes of Ranvier" to the sheath of Schwann, they also may be regarded as *valves* (Fig. 20) in the circulation of the "white substance of Schwann," and axis cylinder substance within their sheaths, allowing of the passage of these substances *towards* the periphery of the nervous system, but opposing a barrier to their regurgitation or

backward flow (Fig. 21), thus securing the integrity of the nerve cells, cerebral and ganglionic, against mechanical pressure and violence, besides aiding in procuring the outlet, or the excretion, of the materials secreted by, and produced in, the nerve cells with their waste products.

The "white substance of Schwann" and its sheath, with the associated "nodes of Ranvier," thus act in the triple capacities of insulating, supporting, and protecting agencies. The occurrence of pain, it might here be remarked, as a nerve phenomenon as well as a symptom of disease, is bound up with the maintenance of the integrity of these structures, and consequently pain may thus be expected to be felt where they are naturally thin,

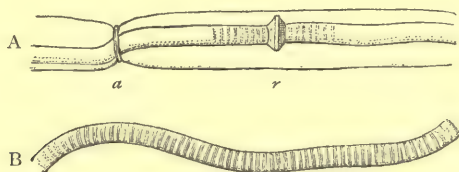


FIG. 21.—NERVE-FIBRES STAINED WITH NITRATE OF SILVER TO SHOW FROMMANN'S MARKINGS IN THE AXIS-CYLINDER. (Ranvier.)

A, Fibre showing a node, *a*, with the constricting ring. The axis-cylinder has become shifted, and the part which was opposite the node and which is stained by the silver, is now below it; *r*, conical enlargement of the axis-cylinder.

B, Isolated axis-cylinder.

as at the distal terminations of the peripheral nerve fibrils in the cutaneous envelope of the body, where the "white substance of Schwann" is said to be usually absent or sparsely distributed, and in the substance of tissues and organs, where sensory nerve fibrils more or less likewise terminate. It may also be expected to be felt wherever the continuity of these protective tissues is interfered with by pressure, or injured by traumatic influences: pain, moreover, in itself may be regarded as a molecular disturbance of the material of the axis cylinders of the nerve fibrils involved, initiated, and realised, or felt, at the spot, or conveyed outwards to the distal terminations of the involved fibrils from the initiating central, or proximal, nerve fibre indirectly or reflexly, so to speak, from the lower centre with which it is related.

EXTRACT VII.

ON CIRCULATION IN ITS GENERAL NERVINE BEARINGS, AND "*CIRCULATIO CIRCULATIONUM OMNIA CIRCULATIO.*"

IN describing the bond of union, or connection, between the circulation of the blood proper, and, what we have called the cerebro-spinal, or nervine, circulation, let us begin with the cerebral capillaries by which the brain pabulum is laid down amid the neuroglial matrix or stroma, where the true nerve elements, as neurons, take their origin and grow. These vessels, by a process of osmosis through their walls, exude this nutritive material into the neuroglial matrix in the more or less amorphous form in which the neurons, *it seems to us*, take it up, by their dendritic processes and attached gemmules (Fig. 22), as distinguished from their axonal processes and cell walls, these latter being mainly insulating and protective, and surrounded by peri-saccular and peri-axonal lymph spaces. Within the matrix of the neuroglial tissue it seems to us that the terminating peri-vascular spaces, and incipient or nascent peri-saccular and peri-neural spaces, merge or unite and "give and take," thus joining the peri-vascular and the peri-neural lymph circulation into one "system of circulation." In other words, we see here a circulation which secures that the brain and cord and nerves are floated in lymph, or fluid, that they are supported by a column of fluid internally, and that the entire substance of the neuroglia wherever existent, in brain, or cord, or ganglionic enlargement, is inter-penetrated by the same. Thus are provided support and protection, with facilities for nutri-

tion and elimination, all of which are of the most vital importance to these the most important organs of the body.



FIG. 22.—RAMIFIED NERVE-CELL FROM ANTERIOR CORNU OF SPINAL CORD OF MAN. (From Gerlach.)

a, axis-cylinder process. *b*, clump of pigment granules. Above the cell is seen part of the network of fibrils mentioned in the text.

On the Mechanisms of Cerebro-Spinal Lymph Excretion.

The cerebro-spinal lymph, when formed, passes into the cerebro-spinal intra-spaces and inter-spaces along the perivascular and peri-neural spaces or canals, and thus conveyed, fills or occupies the ventricles of the brain, the central canal of the cord, and the sub-arachnoid and sub-dural spaces; and being a locally fluctuating and varying quantity, we

must look to this circumstance for a means of obviating the dangers arising to the functional powers of the important structures composing the nervous system. Therefore, notwithstanding that we have been *taught to consider the cerebro-spinal cavity a "shut sac,"* we have satisfied ourselves it is not so, because we have discovered in a continuation of our enquiry into the subject of cerebro-spinal lymph *circulation*, so far as it is applicable to the elucidation of the problem, and in so far as it is required to complete our survey of the nervine circulation, that it is, on the contrary, *abundantly perforated and physiologically pervious and porous.*

Moreover, in pursuing these enquiries, we have asked ourselves again and again, is it possible *after all* that the cerebro-spinal cavity *is* a "shut sac"? and have answered ourselves by asking, *is it possible after all* that the most important organs in the body are suspended in, and interpenetrated by, a fluid largely composed of their own debris and noxiously impregnated with the toxins resulting from the exercise of their own structures and functions and for which there are no possible outlets available? To the latter questions we have, therefore, felt constrained to return a negative answer, and, in justification of our unbelief we venture to suggest the following alternative views:

It was once said that "Nature abhors a vacuum," the saying being elicited from its author *under pressure.* We would now say, in all spontaneity, that nature also *abhors* a stasis and toxicity, and *delights* in the *perpetual movement* of matter, whether in large or small masses, or whether in molecular, or stellar, manner and proportions, and in an atoxic condition.

Applying these aphorisms to our consideration of the problem of the disposal of the cerebro-spinal fluid, they enable us to satisfy ourselves that here we are dealing with no exception to the rule of perpetual movement, or circulation, in matter, and that we have only to follow it up to find that nature does not interpose blank walls against which that fluid may contend in hopeless imprisonment, but, on the contrary, that she provides a loopholed, yet carefully guarded circulatory receptacle into which it can

run, or trickle, and out of which it can gravitate spontaneously, or be liberated, by ordered function and mechanism, in non-autotoxic manner and safe degree.

We grant that the cerebro-spinal cavity is *occasionally* a "shut sac," but the *occasion is only* when the quantity of fluid within it coincides with its available space, or when a pathological condition arises in which the natural outlets

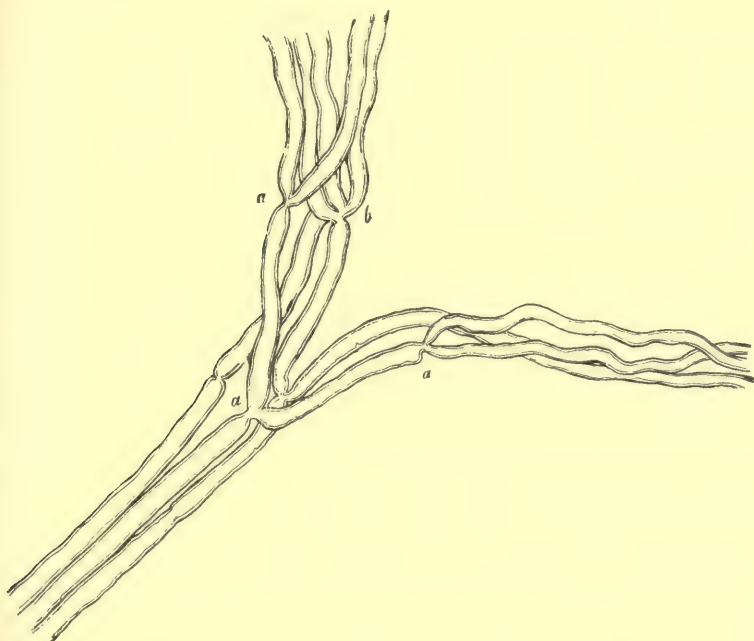


FIG. 23.—SMALL BRANCH OF A MUSCULAR NERVE OF THE FROG, NEAR ITS TERMINATION, SHOWING DIVISIONS OF THE FIBRES. Magnified 350 diameters. (Kölliker.)

a, into two; *b*, into three.

are closed. From this it will be perceived that circulation here is essentially necessary to meet nature's wants in the performance of healthy function and the obviation of disease.

To make plain the nature of this circulation, we shall first consider in some detail the nature of the mechanisms by which it is accomplished, and, in doing so, it may be well to refer shortly to the condition and relations of some of the parts concerned *in its embryonic state*.

At the stage of embryonic development, when the neuro-enteric canal has just been formed, we may infer that its structural continuity warrants the assumption that there is also functional continuity, and that there are, therefore, common inlets and common outlets to and from the common canal. That being so, we are warranted further in inferring that with the developmental differentiation which afterwards takes place at the posterior inferior aspect of the canal, the common structural and functional attributes are, to some extent, maintained, or, at least, that the separation of the canal into two parts is not structurally absolute, and therefore that there still continues a *sympathy* between the two and a *physical union* sufficient to maintain a *modified circulation*: in fact, just such a connection as can keep open a channel, or channels, of escape for the super-abundant fluid contents of the cerebro-spinal cavity at its posterior extremity. In the process of developmental separation of the neurenteric canal into two divisions and their reunion anteriorly, the differentiating and uniting or metamorphic structures laid down between them are left perforated and patent—patent, that is to say, on the principle of the safety-valve.

These perforated areas, or sections, of the cerebro-spinal, meningeal, and ventral structures must, therefore, be looked for where the neural and ventral canals were originally united, and where they were likewise originally separated, and there we find them—anteriorly in the nasal fossæ, the pharynx, and the hypophysial mechanism, with its connected glosso-pharyngeal excretory structures, the tonsils, lateral and pharyngeal, the uvula, and the tongue; and posteriorly in the peri- and endo-anal textures.

Besides these three special outlets, we must here express it as our deliberate opinion that every nerve, cephalic and spinal, which leaves the cerebro-spinal cavity—and of course they all do—takes with it at least two surrounding open spaces, the continuations of the sub-arachnoid and sub-dural spaces (Fig. 24), which afford an additional and, in fact, continuous chain of openings by which, as occasion requires, the cerebro-spinal fluid can be run off. We wish it, thus, to be understood that we believe in the continuity of the cerebro-spinal meninges and the inner layers of the neuro-

lemmæ. In other words, that the meningeal coverings of the various nerves are *not reflected back* into the cerebro-spinal cavity, but that they *continue* or *progress* with their dividing interspaces to the ultimate extremities of each terminal fibre, both sensory, motor, and sympathetic

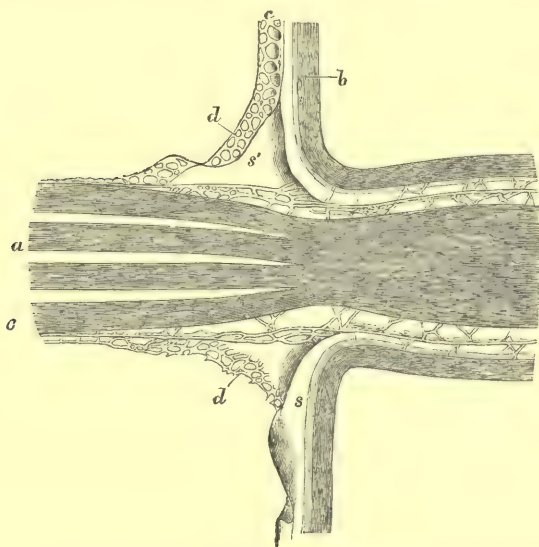


FIG. 24.—SECTION THROUGH THE PLACE OF EXIT OF A SPINAL NERVE-ROOT THROUGH THE DURA MATER. (Key and Retzius.)

a, bundles of the nerve-root becoming collected into a single bundle as they emerge ; *b*, dura mater ; *c*, arachnoid ; *d*, a reticular lamella of the arachnoid reflected along the nerve-root ; *s*, subdural space ; *s'*, subarachnoid space.

“nervi communicantes,” and that they *end with the nerve endings*. Thus we find, as we strongly suspected we would, that a great series of excretory tubes with safety-valve outlets have been introduced into the mechanism of this cerebro-spinal “shut sac,” subserving, no doubt, important, yea, absolutely essential functions, in the regulation of intra-cranial and intra-spinal pressure and the provision of excretory facilities.

EXTRACT VIII. A.

ON THE ORGANS OF NEURAL EXCRETION.

The Pituitary and Pineal Glands in their Relationship with Cerebro-Spinal Lymph Circulation and Excretion.

IN this connection it appears possible and proper to assign functions of great eliminative, or excretory, importance to the curious and much debated structures known as the pituitary (Fig. 29) and pineal glands. Thus the pituitary gland, situated in the *sella tursica*, and surrounded by an extension of the venous circulation of the brain called the circular sinus, consisting of a series of blood spaces or "back-water pools," so to speak, into which we think the more fluid and less effete contents of the contained glandular organ can well and filter, and be carried away in the blood streams issuing therefrom.

The pituitary body is suspended from the infundibulum, into which the third ventricle may be said to drain through a narrow "pit" situated in a hollow in its floor, the less fluid as well as the more solid residual matter of the ventricular cavity, that matter being guided hither by the ciliary activity of its endothelium and the passive influence of gravitation. Situated thus it, the pituitary body, must become the receptacle of a mixture of materials, consisting of cerebro-spinal lymph, endothelial cell debris, neuroglial oozings, and whatever else obtains an entrance into it, which it must of anatomical necessity dispose of, and *this*, we claim, must be *its function*; and surely no mean function, yea, a function second to none in the whole category of glandular functions in

its direct bearings on the great problem of life and health. In disposing of this great mass of excretory material, its anciently believed, but now denied glandular texture and character must simply be "what is required" to enable it to deal *effectually* with it. Hence, we may be prepared to find that the serous or fluid part of it can effect an easy exit through its wall into the surrounding blood channels, leaving the residual or true pituitary portion to be dealt with by its proper gland textures.

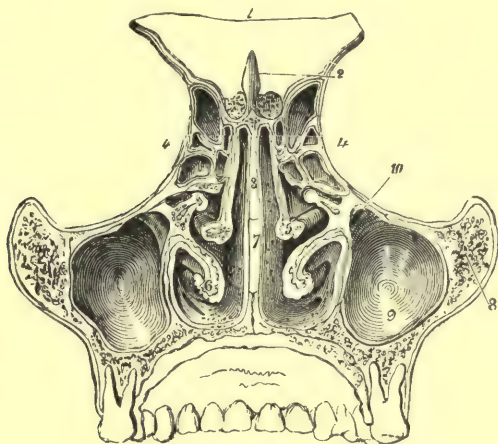


FIG. 25.—TRANSVERSE VERTICAL SECTION OF THE NASAL FOSSÆ SEEN FROM BEHIND. (Arnold.) $\frac{3}{4}$.

1, part of the frontal bone; 2, crista galli; 3, perpendicular plate of the ethmoid; between 4 and 4, the ethmoidal cells; 5, right middle spongy bone; 6, left lower spongy bone; 7, vomer; 8, malar bone; 9, maxillary sinus; 10, its opening into the middle meatus.

This process of *excretion* may, therefore, be regarded as a *sifting* and *cleansing* process, and the central part of the *scavenging* economy of the *cerebro-spinal lymph highways and byeways*. We feel constrained likewise to claim for the pineal gland that it has been *properly named* by the early exponents of anatomical learning, and that its later nondescript character has been wrongly assigned to it, and we claim *further* that it plays a part in the excretory work of the third or central ventricle.

The pineal gland occupies anatomically a very different position from that of the pituitary, viz. the roof, instead of the floor of the ventricular cavity, and so of necessity

it must act in a much more *intermittent* manner, the one (the pineal) only acting when the ventricular space is full and "running over," so to speak, while the other (the pituitary) must always be more or less active. Hence we may assume that it disposes of only the more fluid contents of the overflowing space, the more solid gravitating and being swept away into the more dependent gland, and, consequently, we may be prepared to find that any solid materials found in it will represent the crystalline or

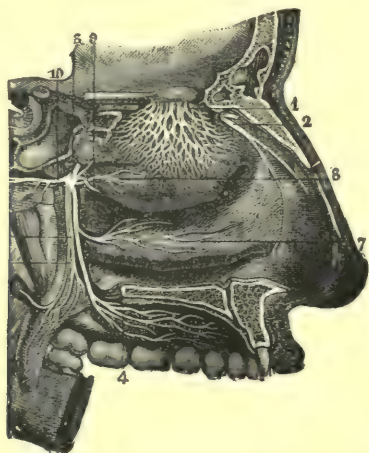


FIG. 26.—NERVES OF THE OUTER WALL OF THE NASAL FOSSÆ. (From Sappey, after Hirschfeld and Leveillé.) $\frac{3}{8}$.

- 1, network of the branches of the olfactory nerve, descending upon the region of the superior and middle turbinated bones; 2, external twig of the ethmoidal branch of the nasal nerve; 3, sphenopalatine ganglion; 4, ramification of the anterior palatine nerves; 5, posterior, and 6, middle divisions of the palatine nerves; 7, branch to the region of the inferior turbinate bone; 8, branch to the region of the superior and middle turbinated bones; 9, naso-palatine branch to the septum cut short.

earthy matter held in solution or suspension by the comparatively *clean supernatant* fluid passing through it, and this is really what we find, the substances usually observed being crystals or accretions of carbonate of lime and phosphate of magnesia, in, or around, a matrix, or nucleus, of organic material.

It is, therefore, obvious that the conclusions come to by the earliest observers regarding the structural characteristics of these bodies are really true, in the sense that their structures are true glands, and, consequently,

that we are warranted in claiming that their true functions are not really cerebral, or nervine, but, as their title implies, secretory, or excretory, or what may be called vehicular.

These views seem to us to open wide fields of investigation and research for the physiologist, pathologist, and clinician of a most promising character, the following up of which we think is bound to repay, both in additions to our exact and scientific knowledge, and our practical resources.

Moreover, the embryological study of the nervous system affords the means, not only of tracing the evolution of its component parts, but of perceiving the hidden meaning of the existence of these textures known as the pituitary and pineal glands, which are now regarded as

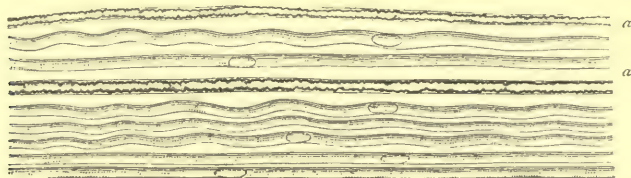


FIG. 27.—NERVE-FIBRES FROM THE OLFACTORY MUCOUS MEMBRANE. (Max Schultze.) Magnified between 400 and 500 diameters.

From a branch of the olfactory nerve of the sheep; at *a, a*, two dark bordered or medullated fibres, from the fifth pair, associated with the pale olfactory fibres.

the anatomical “survivals” of once important organs in the everyday active life of some of our remote ancestors, or progenitors. This latter view, however originated and sanctioned, may be highly convenient as a means of saving further trouble, and of satisfying the *amour propre* of some enquirers after truth, but is highly objectionable, inasmuch as it shelves the needed investigation of the problems involved and deprives mankind of the practical benefits to be derived therefrom. *Survivals forsooth!* 'Tis nothing less than an insult to *nature*, and an impeachment of her working and administration of the law of “evolution,” to manufacture and propagate this story of her prodigality in the use of most valuable cephalic, or brain, space as a museum for the storage of obsolete organisms, and her persistent exhibition of a juvenile affection for the display of some of the works of her “*prentice*” hand in this, the

gallery of her latest, best, and finest productions ! These structures, called pituitary and pineal glands respectively, are illustrations of the truth of this exclamation and contention, and, it seems to us, that their more exhaustive study will reveal many facts indicating that they are structures of the greatest functional importance in the regulation of the cerebro-spinal lymph circulation, a circulation of equal importance with the great blood circulation, and a circulation, in fact, emanating from the blood circulation, and the last of the *great series* of circulations

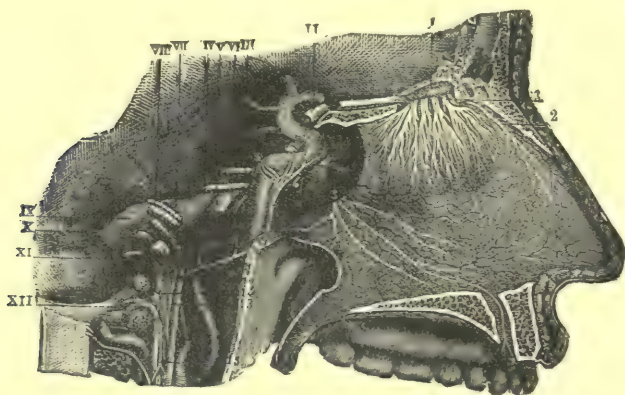


FIG. 28.—NERVES OF THE SEPTUM NASI, SEEN FROM THE RIGHT SIDE.
(From Sappey, after Hirschfeld and Leveillé.) 3.

I, the olfactory bulb ; 1, the olfactory nerves passing through the foramina of the cribriform plate, and descending to be distributed on the septum ; 2, the internal or septal twig of the nasal branch of the ophthalmic nerve ; 3, naso-palatine nerves.

involved in the *chain of vital processes* called by the names deglutition, digestion, absorption, circulation proper, nutrition, assimilation, secretion, and excretion. Thus, in the earliest stages of embryonic development and the evolution of the nervous system, we observe facilities produced and maintained for the free circulation of intra- and extra-nervine fluids : we perceive, also, that the functional rôle of these fluids is twofold, namely, to be a means whereby the results of nerve structure waste are floated out of the intra- and extra-nervine spaces, and the enclosed structures kept "sweet and clean," in order that their vitally important functions may be performed free from friction and auto-interference, in order that the mental

and physical output, so to speak, may reach its highest level of production, as well as to afford a means of mechanical support, protection, and inhibition to the whole component parts of the systemic nervous system.

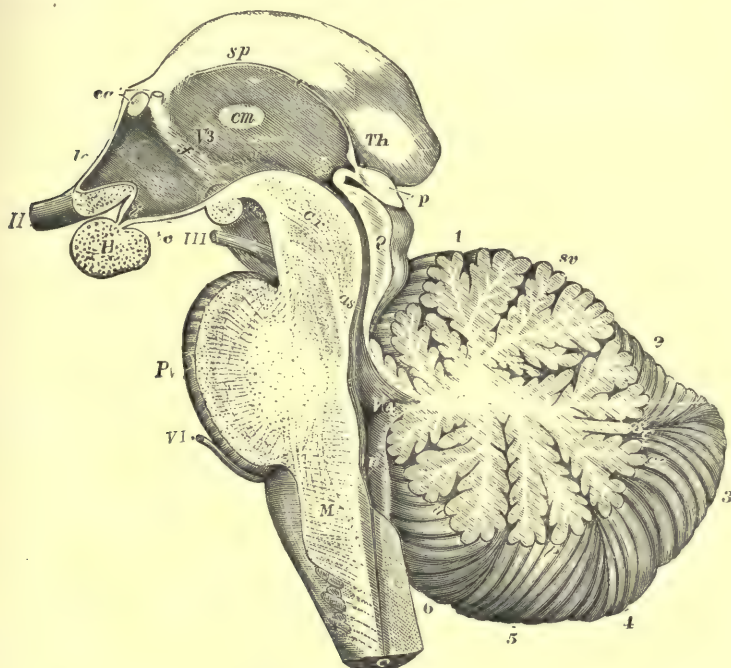


FIG. 29.—RIGHT HALF OF THE ENCEPHALIC PEDUNCLE AND CEREBELLUM AS SEEN FROM THE INSIDE OF A MEDIAN SECTION. (Allen Thomson after Reichert.)

II, right optic nerve; behind it the optic commissure divided; III, right third nerve; VI, sixth nerve; V₃, third ventricle; Th, back part of the thalamus opticus; H, section of the pituitary body; p, pineal gland; below its stalk is the posterior commissure; c a, anterior commissure divided, and behind it the divided anterior pillar of the fornix; l c, lamina cinerea; i, infundibulum (cavity); t c, tuber cinereum; behind it the corpus albicans; f, mark of the anterior pillar of the fornix descending in the wall of the third ventricle: c m, commissura mollis; s p, stria pinealis or peduncle of pineal gland; Q, lamina quadrigemina; a s, aqueduct of Sylvius near the fourth ventricle; cr, crus cerebri; P V, pons Varolii; M, medulla oblongata; and behind these the cerebellum.

In what may be called the “vesicular” stage of development of the central nervous system, we find that its more solid nerve elements or neurons group or arrange themselves in tubular fashion around a central cavity, which is afterwards to be known as the cerebro-spinal ventricular spaces and central canal respectively, in the lumina of which is secreted by the choroid plexuses the

cerebro-spinal fluid. This fluid, as are all fluids within an organised body, is not allowed to flow at large, but is confined within well-defined limits, secured here by the growth of certain containing membranes, which ultimately become the meninges of the brain and spinal cord, and the neurilemmar coverings of the nerves respectively.

The growth of these containing membranes, and the circulation and retention of their contained fluid, necessi-

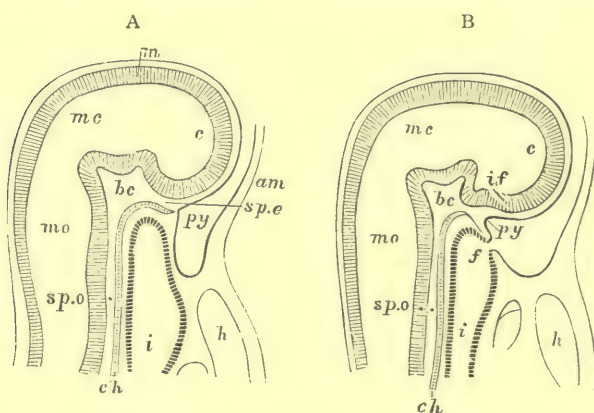


FIG. 30.--VERTICAL SECTION OF THE HEAD IN EARLY EMBRYOES OF THE RABBIT. Magnified. (From Mihalkovics.)

A. From an embryo of five millimetres long.

B. From an embryo of six millimetres long.

In A, the faucial opening is still closed; in B, it is formed; *c*, anterior cerebral vesicle; *mc*, meso-cerebrum; *mo*, medulla oblongata; *m*, medullary layer; *if*, infundibulum; *am*, amnion; *spe*, sphenothymoidal; *bc*, central (dorsum sellae), and *spo*, sphenoccipital parts of the basis cranii; *h*, heart; *f*, anterior extremity of primitive alimentary canal and opening (later) of the fauces; *i*, cephalic portion of primitive intestine; *ch*, notochord; *py*, buccal and pituitary involution.

tates the provision of a series of excretory mechanisms, or organisms, whereby its quantity can be maintained in "balanced ratio," and the ceaselessly recurring disturbances and vicissitudes of the central nervous system neutralised. Here, then, in this connection, we may see in the very early appearance of the pituitary and pineal mechanisms, or organisms, examples of that provision, as well as a vindication of the views of the earliest anatomists regarding their truly glandular structure. The embryonic evolution of the pituitary gland (Figs. 28, 30, 32) in structure and function is marvellously completed and

maintained in post-natal growth and life, and the rôle of that body, in its association with the production of

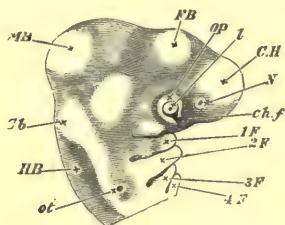


FIG. 31.—SIDE VIEW OF THE HEAD OF AN EMBRYO-CHICK OF THE THIRD DAY. (From Balfour.)

CH, cerebral hemispheres; *FB*, thalamencephalon; *MB*, midbrain; *CB*, cerebellum; *HB*, medulla oblongata; *N*, nasal pit; *ot*, auditory vesicle not yet closed externally; *op*, optic vesicle, with *l*, the lens, and *ch.f*, the choroidal fissure (in mesoblast); *1F*, the first visceral fold or plate, the superior maxillary fold slightly indicated above it; *2, 3, 4F*, the second, third and fourth visceral plates with the visceral clefts between them.

certain diseased conditions, becomes highly suggestive when we continue to enquire more deeply into its bear-

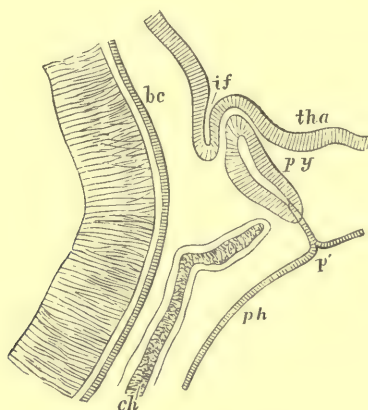


FIG. 32.—VERTICAL SECTION OF THE INFUNDIBULUM AND PITUITARY DIVERTICULUM IN THE RABBIT'S EMBRYO, AFTER THE OPENING OF THE FAUCES. (From Mihalkovics.)

For the earlier stages see Fig. 30, p. 100, A and B. *bc*, dorsum sellae; *if*, infundibulum; *tha*, floor of thalamencephalon; *py*, pituitary diverticulum, now closed; *p'*, stalk of original communication with the mouth; *ph*, pharynx; *ch*, notochord in the spheno-occipital part of the cranial basis.

ings. The earliest stage at which the human embryo shows that evolution of the pituitary gland has begun is when a superior and posterior diverticulation of the

buccal cavity takes place, and when a downward pitting and eversion of the floor of the middle cerebral vesicle shows itself; this stage is followed by the extension and approach towards each other of these diverticulations or expansions, and by their final enclosure in a common cyst wall, within which they afterwards maintain a separate anatomical and histological existence, but co-operate in the

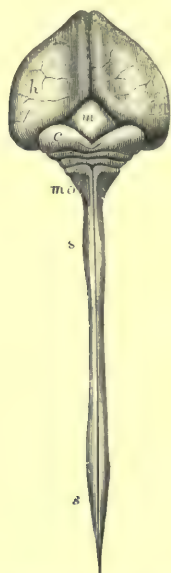


FIG. 33.—BRAIN AND SPINAL CHORD OF A FOETUS OF FOUR MONTHS, SEEN FROM BEHIND. (From Kölliker.)

h, hemispheres of the cerebrum; *m*, corpora quadrigemina or mesencephalon; *c*, cerebellum; *mo*, medulla oblongata, the fourth ventricle being overlapped by the cerebellum; *s s*, the spinal cord with its brachial and crural enlargements.

performance of a common function—their textures, the anterior and posterior lobes respectively, being individually discernible, while their functional work may be regarded as common.

The *sella tursica*, or central basi-sphenoid floor, moreover, is the earliest consolidated and ossified texture of the human skull, and, as such, may be regarded as of primary importance in the support and accommodation of the growing, as well as the mature central nervous system, so far at least as concerns the brain with its dependent pituitary outlet. In association with the formation of this solid floor, as a foundation on which the central great nerve organisms comprised

within the cranial vault can be laid down, developed, or built up in due order, we find that a series of at least three, foramina, or openings, one central and two lateral, is provided whereby the residual materials, resulting from the progress of the great developmental processes then being wrought out, can be removed, to prevent the occurrence of encumbrances and contaminations.

These foraminal exits (Figs. 33, 34, 35, 36) coincide in number and position with the subjacent spongy, and, in

our opinion, excretory bodies known as the tonsils and uvula respectively, hence the frequency with which ail-

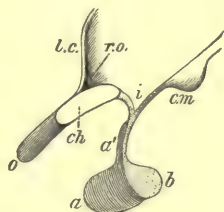


FIG. 34.—SAGITTAL SECTION OF THE PITUITARY BODY AND INFUNDIBULUM WITH THE ADJOINING PART OF THE 3RD VENTRICLE. (Schwalbe.)

a, anterior lobe; *a'*, a projection from it towards the front of the infundibulum, *i*; *b*, posterior lobe connected by a solid stalk with the infundibulum; *l.c.*, lamina cinerea; *o*, right optic nerve; *ch*, section of chiasma; *r.o.*, recess of the ventricle above the chiasma; *c.m.*, corpus mammillare.

ments, involving the basal aspect of the cranial contents, synchronise with those attacking the throat textures, and the grounds for inferring that this is due to structural as

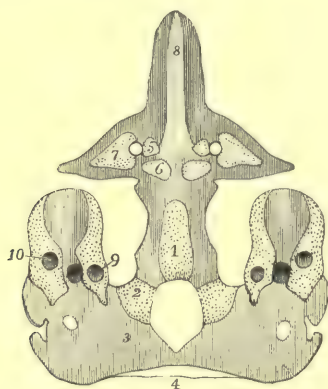


FIG. 35.—VIEW FROM BELOW OF THE CARTILAGINOUS BASE OF THE CRANIUM WITH ITS OSSIFIC CENTRES IN A HUMAN FOETUS OF ABOUT FOUR MONTHS. (From Huxley, slightly altered.)

The bone is dotted to distinguish it from the cartilage, which is shaded with lines. 1, the basilar part; 2, the condyloid or lateral parts; and 3, 4, the tabular or superior part of the occipital surrounding the foramen magnum; 5, centres of the presphenoid on the inside of the optic foramen; 6, centres of the post-sphenoid; 7, centres of the lesser wings or orbito-sphenoid; 8, septal cartilage of the nose; 9 and 10, parts of the labyrinth.

well as functional continuity and inter-dependence. Therefore, a meaning is thus given to the hitherto apparently accidental coincidence of head and throat, as well as face affections, and a key supplied whereby the most effective

treatment may be applied to them, on somewhat definite and scientific lines, instead of on the rather empirical and haphazard principles which have hitherto been relied upon in the absence of definite anatomical and physiological bases; for instance, we may perceive common, or kindred, causes at work along definite lines, anatomical and histological, in the production of a common cold, a coryza, or an influenza, the running at the eyes and nose, the headache, the nasal and pharyngeal catarrh, with the early associated local and general symptoms, following each

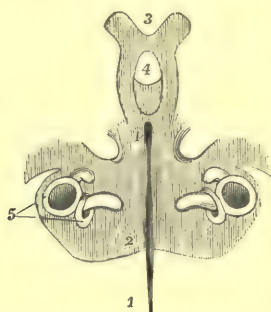


FIG. 36.—THE LOWER OR CARTILAGINOUS PART OF THE CRANIUM OF A CHICK OF THE SIXTH DAY. (From Huxley.)

1, 1, chorda dorsalis; 2, the shaded portion here and forwards is the cartilage of the base of the skull; at 2, the occipital part; at 3, the prolongations of cartilage into the anterior part of the skull called *trabeculae cranii*; 4, the pituitary space; 5, parts of the labyrinth.

other, or occurring simultaneously, according to which part of the involved mucosa, Schneiderian, or pharyngeal, is first invaded by the *materies morbi*, thus pointing the way to secure the amelioration, or cure, of these oft-recurring and sometimes dangerous affections. A *common cold* is, of course, most frequently due to mere *mechanical* disturbance of the process of the distribution, or circulation, of the cerebro-spinal fluid, and disappears spontaneously and without the necessity for medical intervention by the unassisted operation of the regulative influences inherent in, and the automatic health-preserving forces possessed by, all living organisms.

EXTRACT VIII. B.

ON THE POSTERIOR OR COCCYGEAL GLANDULATURE AND EXIT FROM THE CEREBRO-SPINAL LYMPH CAVITY.

THE third great outlet from the cerebro-spinal cavity referred to, viz. the posterior, or peri-anal, and most probably recto-anal as well, can be traced from an early stage of the development of the embryo as the neurenteric canal, which at a subsequent state of development becomes separated into two distinct canals which in time become respectively the cerebro-spinal and intestinal canals.

In the inter-space formed by the process of separation of these two canals the body called the coccygeal gland or glomerulus is evolved or developed from the metamorphic structures, and continues to secure and maintain a connection between the separated cavities, by virtue of its union with what may be described as other metamorphic remains or transition structures.

In our opinion the posterior outlet from the cerebro-spinal cavity contended for is secured in the following way and by the following means, viz. : In the matrix of the texture of the dividing material, or wall of division, are laid down, or rather more exactly, left, the following structures which seem to represent, not survivals only, but an organised system of vessels and organs whose office is one of excretion from the posterior end of the cerebro-spinal cavity, and whose continuity and integrity are therefore of great importance, not only in regulating intra-spinal pressure, but in providing a means by their functional attributes of maintaining the moisture and

consequent flexibility of the recto-anal and peri-anal textures, while acting as excretory organisms. The first of these structures is the "*filum terminale*" (Figs. 37, 38), a structure which is usually regarded as merely ligamentous, but which, to us, represents the continuation of the thecal investments of the spinal cord, and which, if not hollow, is

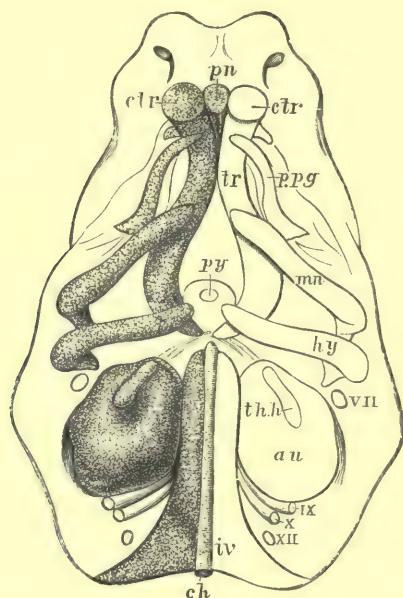


FIG. 37.—PLAN OF THE SKULL, ETC., OF THE EMBRYO PIG, SEEN FROM BELOW. Magnified ten diameters. (From Parker.)

tr, cartilage of the trabeculae; *ctr*, cornua trabecularum; *pn*, prenasal cartilage; *ppg*, pterygo-palatine cartilage; *mn*, the mandibular arch with Meckel's cartilage; *au*, the auditory vesicle; *hy*, the cerato-hyoid arch; *th.h*, the thyro-hyoid; *py*, the pituitary fossa; *ch*, the notochord in the cranial basis, surrounded by the parachordals (*iv*); *vii*, facial nerve; *ix*, glosso-pharyngeal; *x*, pneumogastric; *xii*, hypoglossal nerve.

porous, and therefore still able by capillary circulation and gravitation, to transmit fluid sufficient to accomplish the objects hinted at above; this structure, we think, will find its natural termination in the coccygeal gland or glomerulus, which will receive its contents and functionate accordingly, but *not* as a mere ligamentous attachment to the coccyx as ordinarily taught; or, in other words, the *filum terminale* will "excrete" or distil its contents into the coccygeal gland or into what *seems* to be a *ductless*

secretory glandular organism; but the gland (coccygeal) is *not necessarily closed*, and we are satisfied that on close scrutiny it will uniformly be found to empty itself by means of a series of what are anatomically called “modified

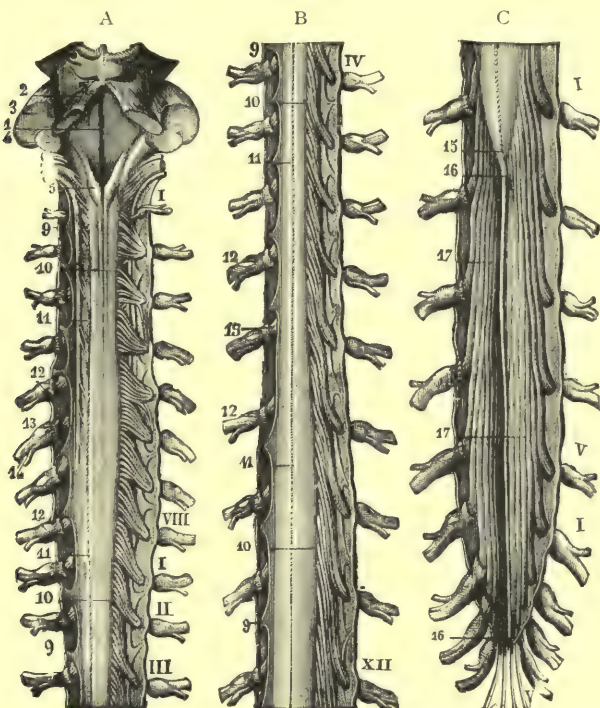


FIG. 38.—POSTERIOR VIEW OF THE MEDULLA OBLONGATA AND OF THE SPINAL CORD WITH ITS COVERINGS AND THE ROOTS OF THE NERVES. (Sappey.) $\frac{1}{2}$.

The theca or dura-matral sheath has been opened by a median incision along the whole length, and is stretched out to each side. On the left side, in the upper and middle parts (A and B), the posterior roots of the nerves have been removed so as to expose the ligamentum denticulatum, 9, and the anterior roots, 13; and along the right side the posterior roots, 10, are shown arising from the posterolateral groove, and passing out through the dura mater. The roman numbers indicate the different nerves in the cervical, dorsal, lumbar, and sacral regions respectively; 11, posterior median fissure; 12, ganglia on the posterior roots; 14, the united nerve beyond the ganglion; 15, tapering lower end of the spinal cord; 16, filum terminale; 17, cauda equina.

sweat glands,” as described by some anatomists, on the margin of the anus, and we think by a series of lymph exits into the interior of the anal ending of the rectum.

The coccygeal glomerulus, or gland, may thus be regarded to some extent as bearing a resemblance in structure and

function to the Batrachian "lymph hearts," and from its being traversed by muscular fibres and supplied with ganglionic nerve cells, therefore possessed of the power of *emptying itself*, or, in other words, it possesses the power of acting as a "bladder" for the caudal extremity of the cerebro-spinal cavity.

The pathological and clinical aspects of these views will, we think, be seen to have most important bearings on both the scientific and practical application of medical and surgical principles and practice. In still further pursuing our enquiries into the rôle of the cerebro-spinal circulation, we would allude in more detail to the more purely nervine aspect of the subject, and its associations on the basis of continuity with the cerebro-spinal part or aspect of the subject.

Anatomically the brain, spinal cord, and nervous system proper are suspended, so to speak, within a fluid medium or covering continuous from the cerebro-spinal cavity to the ultimate termination

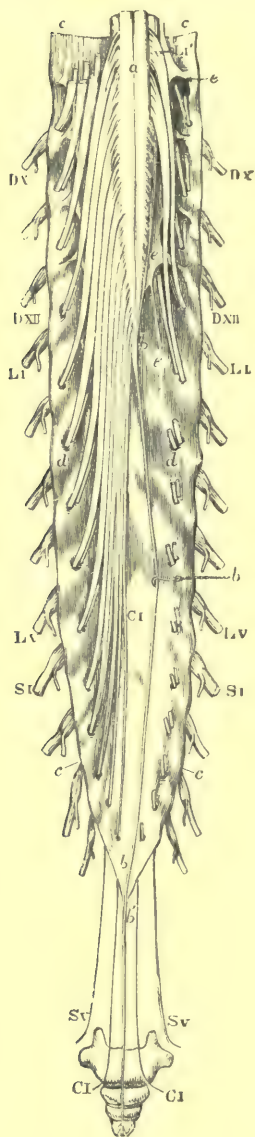


FIG. 39.—POSTERIOR VIEW OF THE LOWER END OF THE SPINAL CORD WITH THE CAUDA EQUINA AND SHEATH. (Allen Thomson.) $\frac{1}{2}$.

The sheath has been opened from behind and stretched towards the sides; on the left side all the roots of the nerves are entire; on the right side both roots of the first and second lumbar nerves are entire, while the rest have been divided close to the place of their passage through the sheath. The bones of the coccyx are sketched in their natural relative position to show the place of the filum terminale and the lowest nerves.

a, placed on the posterior median fissure at the middle of the lumbar enlargement of the cord; *b*, *b*, the terminal filament, drawn slightly aside by a hook at its middle, and descending within the dura-matral sheath; *b'*, *b'*, its prolongation beyond the sheath and upon the back of the coccygeal bones; *c*, the dura-matral sheath; *d*, double foramina in this for the separate passage of the anterior and posterior roots of each of the nerves; *e*, ligamentum denticulatum; *Dx*, and *Dxi*, the tenth and twelfth dorsal nerves; *Lx*, and *Lxi*, the first and fifth lumbar nerves; *Sx*, and *Sxi*, the first and fifth sacral nerves; *Ci*, the coccygeal nerve.

of each individual nerve fibril. The physical necessity for this provision at once becomes apparent when we consider the delicate nature of the structures enclosed, comprehending, as they do, the insulated producers, storers and conductors of nerve force, and the machinery of intelligence, motion, and will structures, therefore indicating the vital importance of preventing the injurious influence and consequences of external disturbances reaching them.

Histologically the continuity of the structures within which the cerebro-spinal fluid is enclosed can be traced from the cranial cavity, the bony wall of which is lined by a series of membranes, each of which accompanies the spinal cord into the spinal canal (or cavity), and thereafter spreads itself around or ensheaths every nerve trunk as it leaves that canal (or cavity), thereafter still travelling with it until it finally loses itself in the terminal extremities of the peripheral nerve fibrils, sensory and motor. These coverings (or sheaths) being thus omnipresent throughout the whole nervous system, it follows that the fluid enclosed within them must also be continuous with its environments and likewise omnipresent, and therefore that it can, and must, exercise the mechanical offices of buffer and protector throughout its whole extent.

We therefore again express our disbelief in the doctrine of the "shut sac," as applied to the lining of the cerebro-spinal cavity, and reaffirm our conviction of "the truth" of what we have attempted to make clear, summing up our contentions in the expression once more of our belief: *circulatio circulationum omnia circulatio*.

Thus we see that the neural lymph circulation, while it belongs to a different order from the hæmal lymph circulation, may still be described as a part of *the great* lymph circulation. It is carried on centrally through the ventricles and central canal, the sub-arachnoid and sub-dural spaces, and peripherally mainly along or between the encircling neural coats—epi, peri, and endo—beginning in the cerebro-spinal cavity and terminating respectively in the skin, the muscles, and the sympathetic nerves—the first through the sensory nerve terminals, and the second through the motor, the latter becoming ultimately directly united with the great sympathetic or hæmal lymph circulation.

EXTRACT VIII. c.

ON THE CIRCULATION AND EXCRETION OF THE CEREBRO-SPINAL FLUID.

AGAIN the cerebro-spinal fluid, being that fluid which surrounds and interpenetrates the whole systemic nervous system, separating the layers of its encircling membranes or meninges and neurilemmæ, thereby preventing friction and concussion amongst its component parts and floating them, so to speak, within a fluid medium which, during neuro-muscular activity, secures their individual freedom and liberty of action, and the certainty and precision of their united employment.

In the condition of bodily rest the extent of its movements or circulation is reduced to a minimum ; in the condition of bodily activity, however, the extent and range of these movements must be great, according to the violence and duration of that activity ; but under the combined influences of bodily activity and mental excitement a pitch of cyclonic, or tornado, violence of movement may be reached to which there is scarcely a limit. This therefore necessitates the provision of a system of circulatory vessels equal to the strain, whose function will be primarily that of circulation, and secondarily that of protecting the central and enclosed nervous system in all its parts from the effects of that violence.

“Excretion” from the cerebro-spinal cavity of the effete materials collected hither from the neuroglial and nerve structures, consisting of nerve debris or “brain sweat,” and the “thousands upon thousands” of outcast atoms from cell and tube and fibre which constitute the

daily currency of brain and nerve exchange, is of the greatest importance to health, and although the subject, as *localised here*, has to some extent been referred to, we think it has not yet been exhausted, and therefore that it is calling for further discussion.

Physiologically the necessity for a solution of the many problems hinging on this most important, but comparatively little known subject, becomes more and more clamant as the morphological and clinical facts, the bacteriological data, and the generalisations deducible from them accumulate, and *because* the practical bearings of that solution on the clinical work of the physician and surgeon, both diagnostic, therapeutical, and prophylactic, must be estimated as of the first importance; besides, it opens up avenues of possible progress for the sanitarian, and aids in clearing "the field of vision" of the exponents of *preventive* medicine.

In continuation of the discussion, we would reiterate that the rôle of the cerebro-spinal fluid seems to us to be to a large extent *excretory*, and that one of the main functions of the channels, already described as pervading the entire nervous system, would seem to us to be to *afford a means of direct exit* for the effete and worn-out material resulting from the disintegration of nerve structure due to tear and wear.

The circulation of the blood generally, through the capillaries of the vascular system proper, affords the means by which nutritive materials are conveyed to where they are required, and whereby osmosis or molecular circulation, into the tissue matrix and enclosed tissue spaces, through the walls of these vessels they finally reach, by physiological selection, the various textures and organs composing the body, and become appropriated and incorporated by them. This process (the nutritive) having been accomplished, and a variable period of *textural incorporation* enjoyed by these materials, what remains of their intra-corporeal journeyings and wanderings is resumed. In other words, after their brief period of incorporation and settled (?) tenancy of the bodily fabric, and their brief span of communal existence is, so to speak, ended, when in turn they become worn by atomic, or

molecular, circulation, and disintegrated by use, their journey into the blood stream is accomplished through the lymph spaces, channels, and vessels: and here comes into view a great and hitherto unanswered question, a question underlying all theories of nutrition and excretion—the question of whether these effete and outgoing materials become mixed with the incoming and nutritive materials, and whether a serious *seeming* error in the “plans of nature” has not been perpetrated. In framing an answer to this question as to the possible contact and admixture of effete, and outgoing, with nutritive, and incoming, materials, within the most vitally important structures of the body, we would regard it as almost a necessary duty to invite the attention of those interested in such problems to the matter, as of greater importance than anything that meantime we could advance at this stage of our enquiry.

Here, nevertheless, we would in a qualified and tentative way conclude that the removal of the effete materials *from the nervous system, as distinguished from the rest of the system*, is effected by the peri-, epi-, and endo-neural channels, and that therefore the nervine excretory mechanism is almost, though not quite (the exception being musculo-nervine or neuro-muscular), *isolated*. In other words, and to make the various steps of the problems involved clearer and more comprehensible, we would recapitulate shortly what we have already advanced, thus—the blood circulation carries *directly to nearly every structure* of the body what nourishment it requires, the great exception being the brain and systemic nervous system, where the blood circulation, instead of delivering the nutritive materials directly to the neuronal structures, lays them down and stores them, so to speak, in the stroma of the neuroglia, where they are taken up as required by the gemmules and dendrons of the nerve cells, and conveyed to the various intra-cellular structures and distally attached nerve fibrils or axons, where, after forming for a time constituent parts of the nervous structures mentioned, they move on to the terminal extremities of these axons, and are detached there as epidermis or as sarcous substance, the latter joining the hæmal lymph and returning into the blood.

Continuing, we would recall that the processes of cerebro-spinal circulation and excretion are accomplished through the complicated series of spaces, inter-spaces, channels, and terminal outfalls found in, and surrounding, the entire nervous system, comprising brain, spinal cord, and nerves, systemic and sympathetic, by the agency of capillary force, mechanical displacement, gravitation, not to mention the occult operation of what might be called vital hydraulics and hydro-dynamics.

The vessels, as we may call them, through which all this cerebro-spinal fluid passes, consist of the meninges with

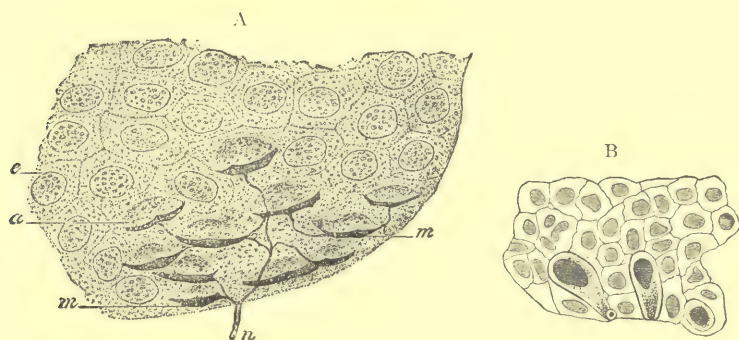


FIG. 40.—A, TWO TACTILE CELLS IN THE DEEPER PART OF THE HUMAN EPIDERMIS. (Merkel.) B, ENDING OF NERVES IN TACTILE DISCS IN THE PIG'S SNOUT. (Ranvier.)

n, nerve-fibre; *m*, terminal menisci or tactile disks; *e*, ordinary epithelium-cell; *a*, altered epithelium-cell, to which the meniscus is applied.

their inter-spaces, the peri-neural extensions of these meninges with the neurilemmar inter-spaces surrounding the nerve fibres, fibrils, and terminal arborisations.

True, a good deal of what has been advanced here and elsewhere in this diary requires more complete anatomical decipherment and exact histological proof before its acceptance can be absolutely claimed, but also true, we, so far as our own observation enabled us, and so far as we could procure materials from other sources published, and otherwise to assist us, we have confined ourselves in pronouncing our disbeliefs in accepted doctrines and in formulating our own views respecting many of them, to the use of strict methods of induction.

Connected with the economy of nervine excretion we ought, perhaps, to have *shortly* related or recalled how and by what means it is *intrinsically* accomplished.

The various openings, or rather series of openings, by which the effete materials floated into the great body of the cerebro-spinal fluid find an exit may be named as follows:—the nasal, the pituitary, the coccygeal, the cutaneous, and the muscular, and, connected with the latter, the general lymphatic.

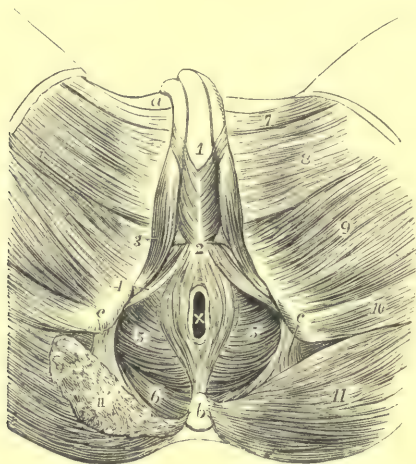


FIG. 41.—SUPERFICIAL MUSCLES OF THE PERINEUM IN THE MALE.
(Modified from Bourger.) (A.T.) $\frac{1}{4}$.

a, spine of the pubis; b, coccyx; c, placed on the tuberosity of the ischium, points by a line to the great sacro-sciatic ligament; X, anus; 1, placed on the corpus spongiosum urethrae in front of the bulbo-cavernosi muscles; 2, central point of the perineum; 3, ischio-cavernosus; 4, transversus perinei; 5, levator ani; from 2 to b, external sphincter of the anus; surrounding X, is the internal sphincter; 6, coccygeus; 7, adductor longus; 8, gracilis; 9, adductor magnus; 10, semi-tendinosus and biceps; 11, on the left side, the gluteus maximus entire; 11', the same cut on the right side, so as to expose a part of the coccygeus muscle.

The first and second, or combined naso-pharyngeal, is afforded through the naso-pharyngeal mucosa, along the olfactory apparatus and associated terminal textures, with the uvula and tonsillo-lingual mucosa. The second (Figs. 39, 41), or coccygeal, is obtained through the *filum terminale* of the spinal cord, the coccygeal gland, and the peri-anal "modified sweat glands" and endo-anal lymph exits. These two outlets being situated at the anterior and posterior, or upper and lower, ends of the cerebro-

spinal cavity respectively, may be looked upon as the main drains and residual excretory channels from the two great structures, the brain and spinal cord.

The third, or cutaneous, may be regarded as affording a great peripheral drainage system to the whole of the sensory nerves, as a safety valve for the escape of superabundant cerebro-spinal fluid when the two first are impeded from any cause and unavailable, hence the importance of recognising their relationship with each other, or interdependence, as one of reciprocity.

The fourth, the muscular, with the attached general lymphatic system, acts as a drainage system to the motor side of the cephalic, cervical, thoracic, lumbar, and sacrococcygeal nerves, as to their anterior roots, and hence drains into the substance of the various muscular structures to which they are distributed, *i.e.* to the whole voluntary muscles of the body. The union of the nervous and muscular systems being one of the greatest intimacy, in fact, of continuity, the drainage from the whole motor area of the systemic nervous system is ejected, or rather injected, into the sarcolemmar and sarcous elements of the muscular textures, to be taken up by the systemic lymph circulation, or driven by continuity from texture to texture until they become finally eliminated from the system, or become pathological entities, or "*materies morbi*" amid the structures in which they may be finally retained.

It will thus, we think, be seen that the maintenance of the patency and integrity of these various drainage systems becomes a physiological work of the greatest importance in its application to the individual, and a hygienic task, to help which is not to be despised by the practices of the healing art, the fourth, or muscular, calling for even special attention. A subsidiary system of this drainage, we think, may also be found into and along the sympathetic nervous system (Fig. 42) through its abundant filamentous connections with the systemic nervous system.

The consideration of the subject of excretion from the cerebro-spinal lymph cavities may be carried a step farther by regarding the orbits with their contained accessory parts as conducive to that function. Thus the eyes are said to "stare," or to stand out of, to "sink," or to be drawn into,

their sockets, the reason of which must be sought for in the distribution of the more liquid and plastic contents of the orbits. These contents are continuous with the contents of the cerebro-spinal cavity, and hence must be affected more or less by the influences affecting that cavity in relation to intra-cranial and intra-spinal pressure.

For example, a paroxysm of whooping cough may result in profuse lachrymation, injection of the conjunctival vessels, with other intra-ocular changes, to which may be added more or less swelling of the whole palpebral regions.

Again, an attack of choleraic diarrhoea is usually quickly followed or accompanied by a "sinking" of the eyes, which in this light we may regard as a withdrawal of the fluid usually present within the orbits, through the foramina communicating with the cranial cavity, as a consequence of the strength of the currents, serous or lymph, towards the excreting intestinal mucous surfaces.

These may be regarded as typical examples of the rôle played in the economy of excretion from the nervous system by the "ebbs and flows" of the cerebro-spinal fluid, in its functions of floating that system and providing a means of disposal for its effete materials.

The horizontal position in some individuals, a prolonged act of stooping, or the suspension of the body head downwards, will induce swelling or puffing of the eyelids by, on this theory, allowing the fluid cerebro-spinal contents to gravitate into the orbital cavities through the before-mentioned foramina, the sub-dural and sub-arachnoid spaces being continuous with these cavities.

The condition of the eyes and orbits, so regarded, may, therefore, be looked upon as very "tell tale" by the observant physician and surgeon, and as affording valuable information in the work of diagnosis. Moreover, such questions arise out of the foregoing as whether, or not, tapping might be desirable and practicable periorbitally, or lumbar puncture resorted to as a curative agency, as a means of relief, or for diagnostic purposes.

In the light of these views some obscure problems relating to the origin and progress of such diseases as rheumatism, gout, influenza, ague, etc., seem to have a

means of explanation not hitherto available, or possible, and a possible application of therapeutic principles to their prevention, alleviation, and cure not before in our possession: For instance, to take an example, influenza seems to pass, so far as its "*materies morbi*" is concerned, *through* the nervous system without *necessarily* extending outside of it, or into adjacent structures; thus, the microbe (or its spore) of the disease reaches the cerebro-spinal fluid through the olfactory and other neural channels, and finds the needful medium in the cerebro-spinal lymph in which to develop when the phenomena characterising the attack begin. These "wax and wane," it may be, spontaneously, or it may be by medical help, and convalescence ensues, it may be, without the temperature, pulse, or general health suffering to even a small extent, all this being effected by the excretion of the foreign organisms and their results, or toxins, through the various points of exit afforded in the nasal, pharyngeal, coccygeal, and cutaneous excretory organisms, directly or otherwise by overflowing into the motor or sympathetic areas.

In further connection with the subject of nervine excretion, we might mention some well-marked excretory areas into which the systemic nervine and general lymphatics may have a common point of exit, such as the axillary regions, where the tufts of hair usually grow, the periumbilical region, and the inter-digital regions of the hands and feet.

From this enumeration, and from the description of the naso-pharyngeal and coccygeal points of exit, it will be observed that the excretory organisms connected with the nervous system are usually located in sheltered but abundantly mobile spots, generally at junctures or bifurcations, with the great exception of the cutaneous sweat glands, in order seemingly to afford the most *ready* exits as well as the most guarded, the most yielding, and the most elastic.

Moreover, the local sensations or sensory disturbances, preceding and accompanying the various acts of excretion from these exits seem to be more or less akin in incidence and character, consisting mainly of a disturbance of one or more histologically related sensory nerve fibres of a

more, or less, profound degree, which results in producing such responsive involuntary acts as sneezing, with more, or less, involuntary friction, and more, or less, powerful voluntary agitation of the regions involved, proving that the importance of cerebro-spinal relief is great and must be accomplished.

EXTRACT IX. A.

THE LESSER CEREBRO-SPINAL LYMPH EXCRETORY MECHANISMS, OTIC, OPTIC, AND OTHERS.

THE question here presents itself—Do we see, in the reputed secretory structures of the dual auditory apparatus, productive machinery and raw material enough, so to speak, to meet their large requirements? and in answer to it we think we are warranted, in the presence of the suggested deficiency, in saying, at the least, that we ought to look for means whereby, in case of necessity, they can, or may, be supplemented.

In looking for such means we think we have found them in the passage of "*ready formed*" cerebro-spinal fluid or lymph through the internal auditory meatus (Fig. 43), along the inter-meningeal spaces and coverings of the auditory nerves, which coverings become continuous with the periosteum and membranous textures of the inner ears—their inter-spaces likewise becoming continuous with the peri- and endo-lymph spaces, their respective fluid contents commingling and forming common reservoirs. Thus, we think, is provided a supplementary or, more truly, a *wholesale* lymph supply sufficient for all the requirements of the auditory apparatus, and which, as long as a physiological condition of the structures and fluids concerned is maintained, can be *relied upon*.

The cerebro-spinal lymph enters the hollow structures of the inner ears in the manner mentioned, and leaves them by certain lymph channels, described in text-books on the subject, as well as, we think, by the reputedly blind endolymph ducts, which leave the skull and exude, or

exosmose, their superabundant fluid into the inter-spaces of the *dura mater* behind and below the petrous processes of the temporal bones where it finds a means of circulatory disposal into the extra-dural lymph spaces of the spinal cavity. We take it, also, that a portion of the intra-auditory lymph finds its way by osmosis into the cavity of the middle ear, where it moistens and lubricates the

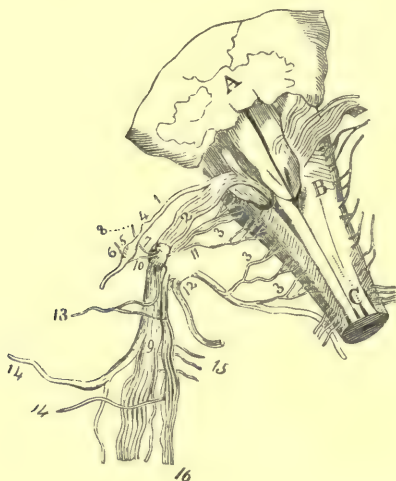


FIG. 42.—DIAGRAMMATIC SKETCH FROM BEHIND OF THE ROOTS OF THE NINTH, TENTH, AND ELEVENTH NERVES, WITH THEIR GANGLIA AND COMMUNICATIONS. (From Bendz.)

A, part of the cerebellum above the fourth ventricle; B, medulla oblongata; C, spinal cord; 1, glosso-pharyngeal nerve; 2, pneumo-gastric; 3, 3, 3, spinal accessory; 4, jugular ganglion of the glosso-pharyngeal; 5, petrous ganglion; 6, tympanic branch; 7, ganglion of the root of the pneumo-gastric; 8, auricular branch; 9, ganglion of the trunk of the pneumo-gastric; 10, branch from the upper ganglion to the petrous ganglion of the glosso-pharyngeal; 11, inner portion of the spinal accessory; 12, outer portion; 13, pharyngeal branch of the pneumo-gastric; 14, 14, superior laryngeal branch; 15, twigs connected with the sympathetic; 16, internal part of the spinal accessory prolonged with the pneumo-gastric.

structures therein and finds a means of exit along the Eustachian tubes into the pharynx, the *fenestra rotunda*, and what remains of the *fenestra ovalis* uncovered, or unoccupied by its attachment to the stapes, constituting the main routes by which the two main lymph reservoirs, or cisterns, of the cochlea and semicircular canals respectively relieve themselves, according to the exigencies of intra-otic pressure. A singular and suggestive phenomenon, somewhat, akin to that observed in the pineal

gland, takes place here in connection with the *foramen ovale* (Figs. 43, 44) and saccule, where there is frequently found a collection of otoliths or crystals, pointing to the operation of similar producing factors on similar fluids, or crystal-containing media.

Before concluding, we perhaps ought to call attention to the fact that analysis of the fluids here mentioned, viz. the

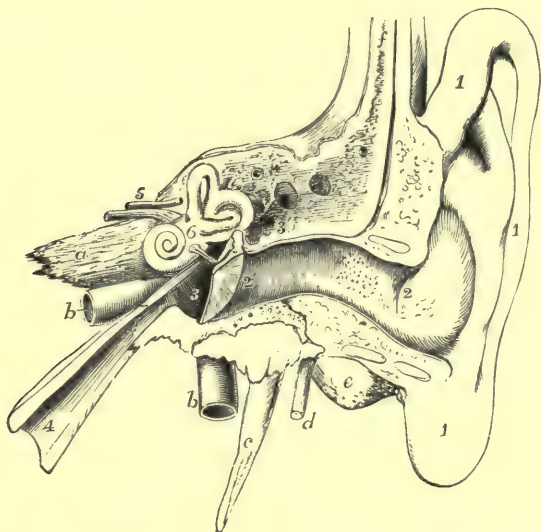


FIG. 43.—DIAGRAMMATIC VIEW FROM BEFORE OF THE PARTS COMPOSING THE ORGAN OF HEARING OF THE LEFT SIDE. (After Arnold.)

The temporal bone of the left side, with the accompanying soft parts, has been detached from the head, and a section has been carried obliquely through it so as to remove the front of the meatus externus, half the tympanic membrane, and the upper and anterior wall of the tympanum and Eustachian tube. The meatus internus has also been opened, and the bony labyrinth exposed by the removal of the surrounding parts of the petrous bone. 1, the pinna lobe; 2 to 2', meatus externus; 2', membrana tympani; 3, cavity of the tympanum; above 3, the chain of small bones; 3', opening into the mastoid cells; 4, Eustachian tube; 5, meatus internus, containing the facial (uppermost) and auditory nerves; 6, placed on the vestibule of the labyrinth above the fenestra ovalis; a, apex of the petrous bone; b, internal carotid artery; c, styloid process; d, facial nerve issuing from the stylo-mastoid foramen; e, mastoid process; f, squamous part of the bone.

cerebro-spinal fluid, and the otic, peri-, and endo-lymph, so far as we have been able to discover, yield substantially the same chemical results, or, at any rate, attest that these results do not differ more from each other than the results obtained by different analysts do from each other when examining the same fluid,—and to claim that we are justified in hazarding the opinion that a common chemical

composition, a continuity of circulatory media, and the common function which they respectively subserve in the

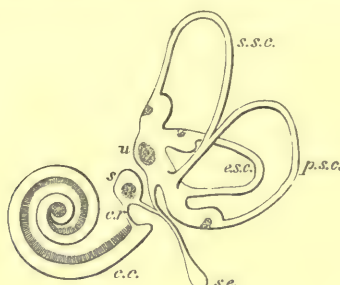


FIG. 44.—PLAN OF THE RIGHT MEMBRANOUS LABYRINTH VIEWED FROM THE MESIAL ASPECT. (E.A.S.) $2\frac{1}{2}$.

u, utricle, with its macula and the three semicircular canals with their ampullae; *s*, saccule; *aq.v.*, aqueduct vestibuli; *s.e.*, saccus endolymphaticus; *c.r.*, canalis reuniens; *c.c.*, canal of the cochlea.

economy of the cerebro-spinal lymph circulation, they are identical in origin, and that the cerebro-spinal lymph



FIG. 45.—MEMBRANOUS LABYRINTH AND NERVOUS TWIGS DETACHED. Magnified. (Breschet.)

k' facial nerve in the meatus auditorius internus; *l*, anterior division of the auditory nerve giving branches, *o*, *m*, *n*, to the utricle and the ampullae of the superior and external canals; *l'*, vestibular division of the auditory nerve, giving a branch, *q*, to the saccule, another to the posterior ampulla, *g*, and a third (*r*) to the cochlea, *r*; *a*, *b*, *c*, ampullae of the superior, external, and posterior semicircular canals respectively, *d*, the united part of the superior and posterior canals; *e*, the macula of the utricle; *f*, the saccule.

producing and distributing machinery is called upon in the physiological or healthy condition of the parts involved to meet *all demands*. It must be regarded, however, as

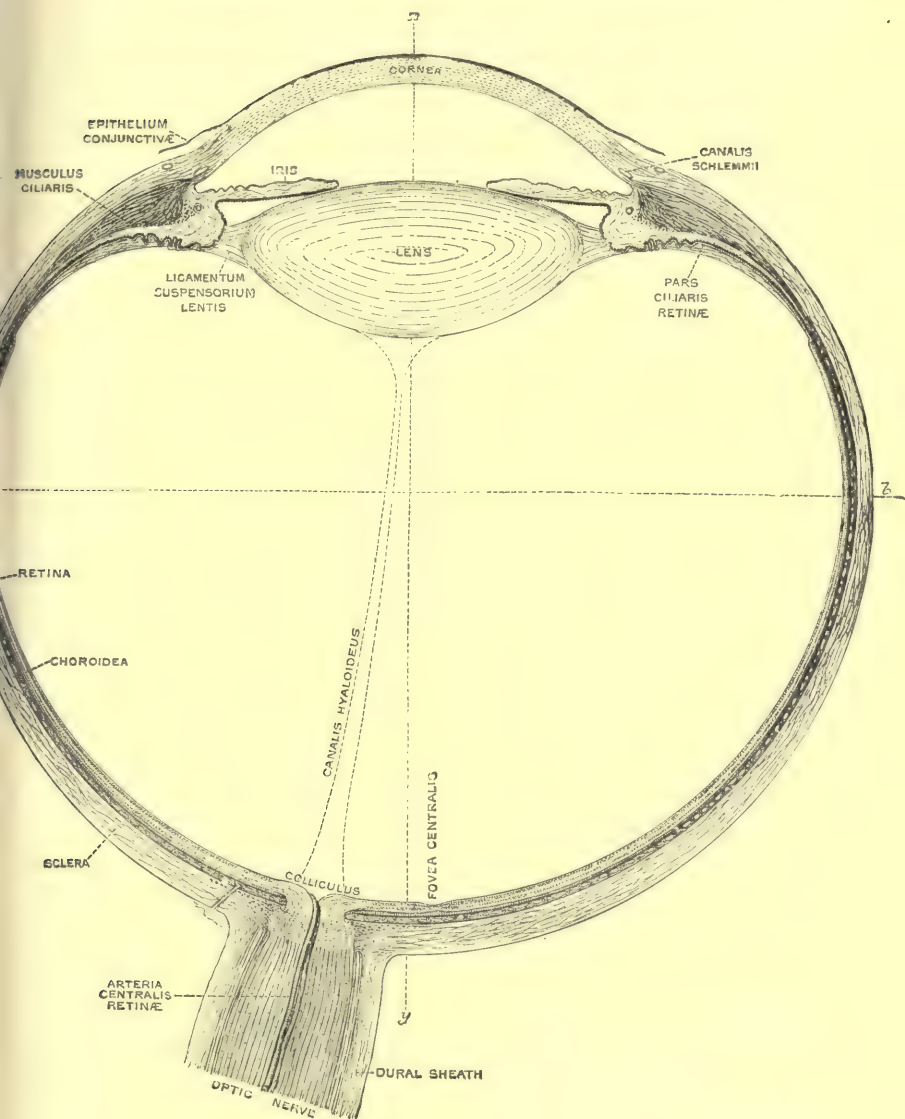


FIG. 46.—DIAGRAM OF THE RIGHT ADULT HUMAN EYE, DIVIDED NEARLY HORIZONTALLY THROUGH THE MIDDLE. (E. A. Schafer.) Magnified five times.

The line *ab* passes through the equator, *xy* through the visual axis of the eye.

likely that in case of obstruction of the channels of supply of this fluid a means exists and can be drawn from

whereby these lymph cisterns can be replenished, and the integrity of the apparatus of audition maintained, and this means, we think, is to be found in the endothelial linings of the inner ears generally, with their surroundings and supporting blood supply. A dual mechanism, therefore, we think, exists in this cryptic region for securing the continuity of auditory sense-impressions and supplying the higher cerebral centres with a highly specialised

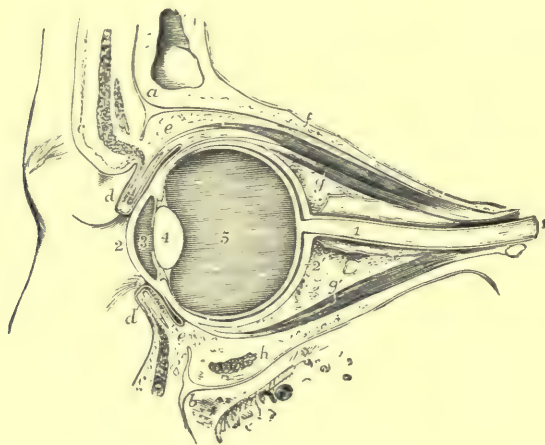


FIG. 47.—VERTICAL SECTION OF THE LEFT ORBIT AND ITS CONTENTS.
(Allen Thomson.)

The section has been carried first obliquely through the middle of the optic foramen and optic nerve as far as the back of the eyeball, and thence forward through the eyeball, eyelids, etc. *a*, frontal bone; *b*, superior maxillary; *c*, eyebrow; *d*, the upper, and *d'*, the lower eyelid, partially open, showing the section of the tarsi, the eyelashes, etc.; *e*, *e'*, the reflection of the conjunctiva from the upper and lower eyelids to the surface of the eyeball; *f*, the levator palpebrae superioris muscle; *g*, the upper, *g'*, the lower rectus muscle; *h*, the inferior oblique muscle divided; *i*, *i'*, the optic nerve divided in its sheath; *2*, the cornea; *2'*, the sclerotic; *3*, aqueous chamber; *4*, crystalline lens; *5*, vitreous chamber.

tributary to the continually needed stream of information from the outer world.

Another region “watered” by the cerebro-spinal fluid, and which affords a means of exit to that fluid when required, is the ophthalmic (Figs. 46, 47), which, divided into two and situated at the anterior aspect of the head where the head and face join, constitutes the most prominent and tell-tale feature of the physical and intellectual microcosm within the organisms of both man and animal.

Here, as in the auditory organisms, the cerebro-spinal fluid seems to perform many very important offices during its passage through, and presence in, the optic organs, ingress to which it obtains along the subdural and subarachnoid spaces (Fig. 47), where they leave the cranial cavity to enter the orbits along the neurilemmar inter-spaces surrounding the optic nerve as well as along the sheaths of the blood-vessels which pass from within the skull to these organs, and which are also accompanied by meningeal sheaths. Here, moreover, is afforded by the plentiful presence of the cerebro-spinal fluid and accumulations



FIG. 48.—MEIBOMIAN GLANDS OF THE LEFT EYELIDS AS SEEN FROM BEHIND.

a, a, palpebral conjunctiva; *1*, lachrymal gland; *2*, openings of seven or eight of its ducts; *3*, upper and lower puncta lachrymalia; *6, 6*, ends of the upper and lower Meibomian glands, of which the openings are indicated along the margins of the eyelids.

of fatty post-orbital material, two padded, or cushioned, chambers in which shock is deadened and freedom of movement secured, so that the two most delicate sense organs can perform their functions without "let or hindrance." Here also, if we patiently follow the windings of the cerebro-spinal lymph circulation of the eyes, we find a succession of spaces and channels leading into the very interior of these organs, and perceive that the vitreous and aqueous humours are but two great pools, or cisterns, (Fig. 46) of that fluid, continuous with and physically—apart from specialised organic matters—indistinguishable from it; and, therefore, to "all intents and purposes" drawn from and *mostly* dependent upon it; moreover, we

are disposed to think that the lachrymal glands (Figs. 48, 49), and other aquiferous textures within the orbits are

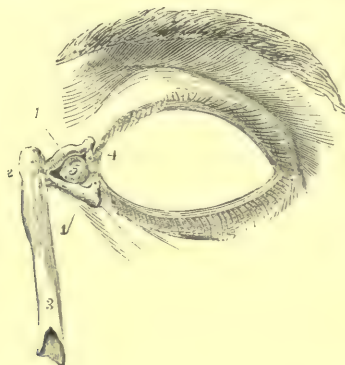


FIG. 49.—FRONT OF THE LEFT EYELIDS WITH THE LACHRYMAL CANALS AND NASAL DUCT EXPOSED.

1, 1, upper and lower lachrymal canals, showing towards the eyelids the narrow bent portions and the puncta lachrymalia; 2, lachrymal sac; 3, the lower part of the nasal duct; 4, plica semilunaris; 5, caruncula lachrymalis.

likely to derive their supplies of fluid from the same source, and along the neurilemmar inter-spaces surrounding their nerve supplies.

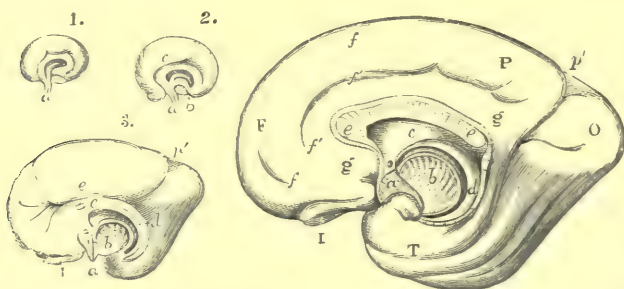


FIG. 50.—SEMIDIAGRAMMATIC VIEWS OF THE INNER SURFACE OF THE RIGHT CEREBRAL HEMISPHERE OF THE FŒTAL BRAIN AT VARIOUS STAGES OF DEVELOPMENT. (From Schmidt.)

1, 2, and 3, are from foetuses of the respective ages of eight, ten, and sixteen weeks; 4, from a foetus of six months. *a*, lamina terminalis or part of the first primary vesicle which adheres to the sella turcica; *b*, section of the cerebral peduncle as it passes into the thalamus and corpus striatum; the arched line which surrounds this bounds the great cerebral fissure; *c*, anterior part of the fornix and the septum lucidum; *d*, inner part of the arch of the cerebrum, afterwards the hippocampus major and posterior part of the fornix; *e*, corpus callosum very short in 3, elongated backwards in 4; in 4, *f*, the marginal convolution; *f'*, calloso-marginal fissure; *g*, gyrus fornicatus; *h*, the parieto-occipital fissure descending to meet the calcarine fissure; *I*, olfactory bulb; *F*, *P*, *O*, *T*, frontal, parietal, occipital and temporal lobes.

If all this be true—and we see nothing anatomically, histologically, or physiologically, in the organisation and

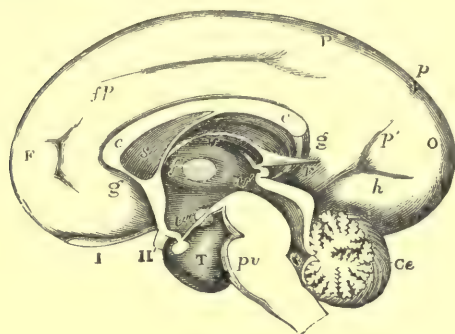


FIG. 51.—VIEW OF THE INNER SURFACE OF THE RIGHT HALF OF THE FOETAL BRAIN OF ABOUT SIX MONTHS. (From Reichert.)

F, frontal lobe; P, parietal; O, occipital; T, temporal; I, olfactory bulb; II, right optic nerve; *fp*, callosal-marginal fissure; *p*, external; *p'*, internal parts of the parieto-occipital fissure; *h*, calcarine fissure; *g*, gyrus fornicatus; *c*, corpus callosum; *s*, septum lucidum; *f*, placed between the middle commissure and the foramen of Monro; *v*, in the upper part of the third ventricle immediately below the velum interpositum and fornix; *v'*, in the back part of the third ventricle below the pineal gland, and pointing by a line to the aqueduct of Sylvius; *r*, in the lower part of the third ventricle above the infundibulum; *r*, recessus pinealis passing backwards from the tela choroidea; *pv*, pons Varolii; *Ce*, cerebellum.

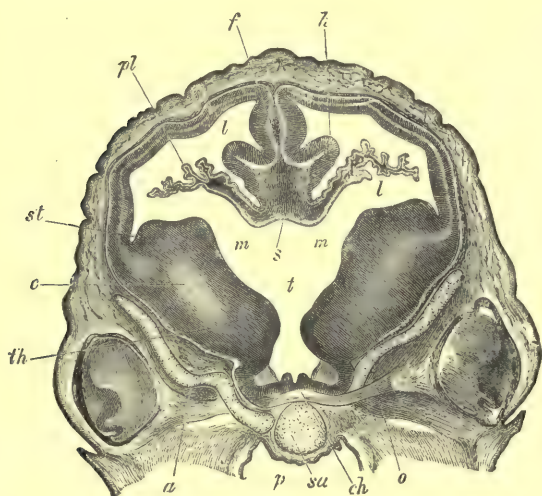


FIG. 52.—TRANSVERSE SECTION THROUGH THE BRAIN OF A SHEEP'S EMBRYO OF 2.7 CM. IN LENGTH. (From Balfour, after Kölliker.)

The section passes through the hemispheres and third ventricle. *st*, corpus striatum; *th*, optic thalamus; *t*, third ventricle; *c*, their divergence into the walls of the hemispheres; *l*, lateral ventricle with choroid plexus *pl*; *h*, hippocampus major; *f*, primitive falx; *a*, orbito-sphenoid; *sa*, presphenoid; *p*, pharynx; *ch*, chiasma; *o*, optic nerve; *mm*, foramen of Monro; *s*, covering of lateral ventricles.

structure of the parts to contradict it, but, on the contrary, and by embryological enquiry, we can clearly satisfy ourselves of its claims to belief—then we think we have established another reason calling for a continuation of this enquiry, with a view to the obtainment of ever required utilitarian results, such as a clearer knowledge of



FIG. 53.—SKETCH OF A SUPERFICIAL DISSECTION OF THE FACE, SHOWING THE POSITION OF THE PAROTID AND SUBMAXILLARY GLANDS. (Allen Thomson.) $\frac{2}{3}$.

p, parotid gland; *p'*, socia parotidis; *d*, the duct of Stenson before it perforates the buccinator muscle; *a*, transverse facial artery; *n, n*, branches of the facial nerve emerging from below the gland; *f*, the facial artery passing out of a groove in the sub-maxillary gland and ascending on the face; *sm*, superficial portion of the submaxillary gland.

the etiology of the diseases of these organs, and their relationships to their structural elements as affected by these views, as, for instance, where discontinuity of usually firmly adherent and coherent textures becomes effected along lines previously open in embryonic conditions, such as occur in the condition known as detached retina.

The enumeration of the special otic and ophthalmic cerebro-spinal lymph excretory agencies, as well as the

more detailed and wholesale olfactory and pituitary outlets, suggest that a kindred excretory phenomenon occurs at the outlets of the salivary glands (Figs. 53, 54), where the more aqueous elements of that fluid, conveyed hither neurilemmically, may be said to afford a basis for the production and discharge of the specific salivary fluids, where their utilisation in the process of digestion is so intimately associated with the glosso-pharyngeal mucosa. It would therefore appear, if these observations are grounded on truth, that a large field for physiological and

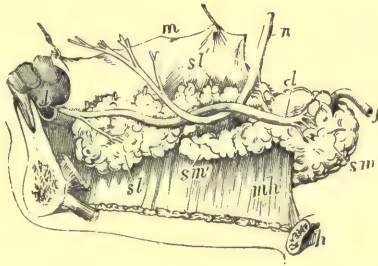


FIG. 54.—VIEW OF THE RIGHT SUBMAXILLARY AND SUBLINGUAL GLANDS FROM THE INSIDE. (Allen Thomson.)

Part of the right side of the jaw, divided from the left at the symphysis, remains; the tongue and its muscles have been removed; and the mucous membrane of the right side has been dissected off and hooked upwards so as to expose the sublingual glands; *sm*, the larger superficial part of the submaxillary gland; *f*, the facial artery passing through it; *sm'*, deep portion prolonged on the inner side of the mylo-hyoid muscle *m*; *sl*, is placed below the anterior large part of the sublingual gland, with the duct of Bartholin partly shown; *sl'*, placed above the hinder small end of the gland, indicates one or two of the ducts perforating the mucous membrane; *d*, the papilla, at which the duct of Wharton opens in front behind the incisor teeth; *d'*, the commencement of the duct; *h*, the hyoid bone; *n*, the gustatory nerve; close to it is the submaxillary ganglion.

pathological research lies open, the active occupation and exploitation of which may result in positive additions to human comfort and happiness.

In this connection we would also draw special attention to the cerebro-spinal lymph excretory régime of the pneumo-gastrics (Fig. 55) in their multitudinous relationships with the thoracic and abdominal viscera, where, besides their specific function of systemic innervation of these organs, they also afford great facilities for the functionally useful outflow of that lymph into their textures, and so passively afford channels by which the progress of morbid agencies can find a free passage from the intracranio-spinal areas to the thoracic and abdominal

visceral areas, and *vice versa*—a doctrine which affords a ready and clear explanation of many puzzling bacteriological and chemico-physiological problems in the etiology

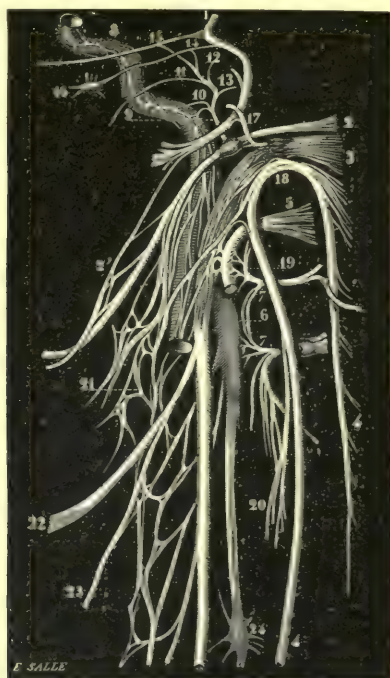


FIG. 55.—DIAGRAM OF THE ROOTS AND ANASTOMOSING BRANCHES OF THE PNEUMO-GASTRIC AND NEIGHBOURING NERVES. (From Sappey, after Hirschfeld and Leveillé.)

- 1, facial nerve; 2, glosso-pharyngeal with the petrous ganglion; 2', connection of the digastric branch of the facial nerve with the glosso-pharyngeal nerve; 3, pneumo-gastric, with its two ganglia; 4, spinal accessory; 5, hypoglossal; 6, superior cervical ganglion of the sympathetic; 7, 7, loop of union between the first two cervical nerves; 8, carotid branch of the sympathetic; 9, nerve of Jacobson (tympanic), given off from the petrous ganglion; 10, its filaments to the sympathetic; 11, twig to the Eustachian tube; 12, twig to the fenestra ovalis; 13, twig to the fenestra rotunda; 14, small superficial petrosal nerve; 15, large superficial petrosal nerve; 16, otic ganglion; 17, auricular branch of the pneumo-gastric; 18, connection of the spinal accessory with the pneumo-gastric; 19, union of the hypoglossal with the first cervical nerve; 20, union between the sterno-mastoid branch of the spinal accessory and that of the second cervical nerve; 21, pharyngeal plexus; 22, superior laryngeal nerve; 23, external laryngeal; 24, middle cervical ganglion of the sympathetic.

and pathological sequence of morbid events, and a means of *linking up* the morbid elements of many apparently disunited and incongruous pathological states of both head and trunk. Thus the simultaneous, or immediately consecutive, presence of similar bacterial organisms, such as

the pneumococcus in the cerebro-spinal cavity, the cardiac, and other thoracic and abdominal structural elements, must be recognised as one of continuity, due to unalterable histological and anatomical relationships, and the same may be said of many allied conditions where disease is spread by the gradual involvement of structurally and vascularly connected structures and organs throughout the whole body.

EXTRACT IX. B.

ENUMERATION OF THE MECHANISMS CONCERNED IN THE ELIMINATION OF CEREBRO-SPINAL LYMPH.

THE excretory mechanisms already described pertain to the nervous system proper and its containing textures. The addendum here dealt with belongs to the extra-nervine aspect of that system, and flows out of what seems to be a possible or probable leakage along the great arterial vessels supplying the brain, viz. the external and internal carotids, as well as the jugular veins. These vessels at their entrance to, and exit, respectively, from the skull, and their distribution within it, are bathed with cerebro-spinal fluid, and supported by it, much in the same way as the cephalic nerves proper are, hence the possibility and probability of leakage along their adventitial coverings, and the subsequent invasion in detail of the cervical and thoracic regions of the body related to these vessels by the residual products of brain waste, and hence the physiological and hygienic necessity for preventing such an occurrence.

The required preventive provision seems to us to be supplied by two so-called ductless glandular bodies, or more probably *lymph hearts*, called the carotid glands, situated respectively on each side of the neck, at the bifurcation of the common into the external, and internal, carotids, where they form the continuations of the common carotid artery. Here the leaking cerebro-spinal fluid is received by the carotid glands in gravitating currents, as they percolate through the arterial and venous adventitial cellular textures, and is prevented from descending into the vital organs below, and rendered

innocuous by the glandular agency of these organs, ere it is permitted to re-enter the blood streams. All this is, no doubt, and may rightly be called highly speculative, but still we hold it to be so strongly reasonable that we have felt constrained to add it to what we have already advanced with regard to the economy of cerebro-spinal fluid excretion, as well as for the purpose of enabling us to assign a *living* "everyday" *working function* to two organisms for which anatomists have hitherto failed to find a probable use. These *cystiform* organs are possessed of the requisite anatomical structure—glandular and neuromuscular—to enable them to perform the work of collection, chemico-physiological treatment, and excretion of whatever fluid can reach them along the adventitial envelopes of the two carotids and jugulars, which are necessarily, anatomically, and histologically, continuous through their envelopes with the dura-arachnoid textures; hence, we are strongly of opinion that they perform this function, a function, moreover, very much akin to that which we have assigned to the coccygeal gland; another organism, furthermore, with which anatomists are accustomed to classify them, preparatory to *shelving* them amongst the *quantities* "negligible," where in a single sentence they are usually *labelled* and consigned to rest in oblivion until next "stock-taking."

We would here *reiterate* the *assertion* in this connection, that no "unnecessary structure" can be allowed evolutionarily, so to speak, *to be repeated in every generation of the human, or other race, with the attributes of a highly organised texture, without its being called upon to perform a work in consonance with its anatomical character and position to justify its retention and prevent its involution and disappearance.* We may thus rest assured that it is altogether unjustifiable to describe any organ, or texture, now surviving in the human body whose function we are ignorant of as a "survival" only, and, therefore, as an encumbrance, which, in these advanced days of evolutionarily determined human destiny, we are warranted, or called upon, voluntarily to neglect, or to sacrifice.

Therefore, we take it that, if the law of evolution is to be believed, and if it is to have a practical bearing

on human progress and happiness, we must disabuse our minds of, and guard against, the great fallacies capable of being perpetrated by the *careless* or *unscientific* use of such terms as *survival*, but *not of the fittest*, and *reversion to earlier*, and, it may be, long since extinct *types*; all which represent *only* the continuous, contemporary, and balanced working of the laws of involution and evolution as *the one* great determining and operative *law of progress*, in the world, inorganic, organic, and human.

Human progress generally, as well as particularly, although the outcome, to some extent, of what seems to be free and independent individual, or communal, human effort, is no exception to the universal incidence of this law, a fact which all human history attests; it, therefore, behoves the votaries of whatever science, or cult, which can in any way affect the rate of that human progress, to put the methods and manners of that science, or cult, so clearly and intelligibly into the possession of their successors, as that it can be afterwards said, in all truth, by these successors, "he that runneth may read."

Since the above was written regarding the carotid glands, or bodies, it has been found that an affection of the neck called the "potato-like tumour" takes its origin from the carotid glands, one, or other, or both, and that it has a course quite distinct from any other known growth in these regions, and is possessed of a structure *endothelial* in character, and just such as could be evolved from occlusion of the excretory outlets of the gland, or glands, with pathological accumulation and formative arrangement of their resultant secretion and tissue elements. We, therefore, feel warranted in claiming this *pathological discovery* as a *proof of the truth* of our *physiological finding* with regard to these much overlooked bodies.

EXTRACT X.

ON THE SENSORY DISTURBANCES, OR ÆSTHETIC PHENOMENA, OCCURRING AT, AND AROUND, THE POINTS OF EXIT OF THE CEREBRO-SPINAL LYMPH, ANTECEDENT TO, AND DURING, EXCRETION.

THAT the character of the disturbances, or feelings, or sensations, is determined by their *locale* we have long observed, and, accordingly, have now become satisfied that the painful feelings and itching sensations experienced at times more or less over the whole sensory surfaces of the body, are most largely situated at the points of exit of the cerebro-spinal lymph from its containing vasculature, viz. from the individual sweat glands of the skin generally, the axillary sweat glands and interdigital surfaces in particular, along with the coccygeal gland *duct vasculature*, the Schneiderian mucosa, and the tonsillo-glossal mucosa.

Obstructed exit of the cerebro-spinal lymph, loaded with, it may be, toxic, and, it must certainly be with effete, matter, gives rise to sensory disturbance at the points of obstructed exit, in degree proportionate, we may conceive, indeed, believe, to the amount of stasis and intensity of toxicity of the lymph in process of excretion, and hence may vary, from the slightest feeling of itching, to the most intense feeling of smarting, or acute pain. Thus local, or general, disturbance may be felt as prurigo at the cutaneous exits, annoying itching in one or both axillæ, and slight or exasperating irritation at, and around, the anus, while slight, or severe, sneezing may characterise involvement of the olfactory exits, and more or less severe pain may be the

outcome of the implication of the pituitary excretional mechanism. We may further conceive, and, when observation and experiment have tested the value of the conception, we are persuaded it will be found true, that many of the other sensory disturbances originating in, and disposed throughout, the sympathetically innervated areas of the body will be found to depend on the existence of similar obstructive phenomena in the final distribution, or elimination, of the sympathetico-systemic lymph within the texture and parenchyma of the parts and organs involved. Thus pneumonia, endocarditis, gastro-enteric catarrh, some hepatic, splenic, and renal troubles, may stand as types of the diseased conditions and sensory disturbances directly traceable to excretion of effete and tainted cerebro-spinal lymph along the pneumogastric and connected sympathetic nervature, when an exit has been denied it through the usual systemic exits, and when, in consequence, it has followed the lines of least resistance, until it has finally been disposed of, as here indicated, freely, or interruptedly.

Contemporary with, or subsequent to, the occurrence of these cerebro-spinal lymph exit sensory phenomena, a local, or general, hyperæmia, or sometimes inflammation, may show itself at, or around, the points of exit, and become the diseased condition for which relief is at last sought. When such is the case it will behove us to note particularly the order and manner of etiological sequence and morbid development of the disorder, so as the more scientifically to obtain the "key to the situation," and thereby to obtain proper indications for treatment. We are convinced that we are warranted in stating that it would not be too great an estimate of the frequency of the relationship of disturbed cerebro-spinal lymph excretion to modified, or morbid, sensory phenomena, were we to put it at fifty per cent., and it may well be much more, of the whole negative and positive departures from the standard of normal physiological æsthesia; therefore, we are strongly of opinion that great practical results are likely to follow from a recognition of the intrinsic value of this estimate in the work of diagnosis, prognosis, and treatment of disease, and that, moreover, by it a clearer light will be shed on the character and nature of some of the most

recondite subjects in the whole category of nervine disease, as it is met with, especially in the peripheral aspect of the nervous system. Itching and pain, perverted, or abnormal, æsthesia, primary and secondary, original and resultant, become the symptomatic finger-posts guiding us along the Aesculapian way, so to speak, and which, when utilised with a due appreciation of, and dependence on, their intrinsic value in the detection of cause and effect, will illuminate and render more traceable the direction of some of its obscure windings and less explored byeways, amid the uncertainty surrounding the genesis and progress of many of the diseases of the peripheral aspect of the systemic, as well as the sympathetic, nervous systems individually and conjointly. Abolished, disturbed, and perverted sensation may often begin and end as simple sensory phenomena, indicating only the most ephemeral interference with the prevalence of normal sensory function, and nothing but a temporary, and generally mechanical, impediment to the operation of the normal sensory physiological conditions and factors at work in the causation of afferent, or sensory, nervine genesis and conduction—the condition disappearing on the removal of the impediment and the restoration of the neural patency of the implicated nervature. When, however, as it no doubt many times is, the impediment to normal sensory innervation is more or less permanent, we may regard the discovery of what the impediment is as affording the necessary indicator of the line, or lines, of treatment to be adopted in the removal of the diseased condition, and the restoration of both healthy structure and function.

Thus pain, and in fact every disturbed sensory phenomenon, becomes of the greatest value to the clinician, in safely guiding him along correct pathological lines, until it becomes possible for him to read, and determine, in altered and disturbed anatomical, histological, and physiological conditions, or characters, the history and progress of the diseased state regarding which his advice has been sought, and consequently the discovery of the most scientific indications for the treatment to be pursued.

No doubt in estimating the practical value of pain and disturbed sensation, in the work of diagnosis, prognosis,

and treatment, it becomes imperatively necessary to differentiate, in the first place, between the systemic and sympathetic nervous systems, as to the part they respectively play in their genesis and persistence, and whether they are singly, or unitedly, concerned, because on this will depend, to a great extent, the exactitude of our appreciation of the diseased condition before us, as well as the success of our remedial and ameliorative procedure.

Roughly speaking, almost all external pain and sensory disturbance emanate from the systemic nervous system, while in the same way, almost all internal pain and sensory disturbance emanate from the sympathetic nervous system, the exceptions being where the affected parts happen to be innervated, to some extent, by both systems. It may, however, be taken for granted that sympathetically initiated pain can only be realised through the systemic nervous system in virtue of the existence of the *nervi communicantes*, and consequent intimate union subsisting between the two nervatures. As types respectively of the two orders of pain, we might cite those proceeding from dermatitis and "bilious colic," so called; the former representing a *visible* peripheral sensory phenomenon, the latter, a *hidden* sympathetico-systemic sensory phenomenon—each affording a strong contrast to the other in point of character and intensity, and requiring for its relief, or removal, the use of a different method of procedure.

Our survey of the genesis and character of pain, or perverted æsthesia, applies also to the motor aspect of the systemic nervous system, and there we find the phenomena displayed in all degrees of intensity, and over small, or large, areas, according to the nature, and extent, of its etiological factors: thus, in acute rheumatism, we have it displayed generally, and less or more locally, when it may involve muscle substance pure and simple, periosteum, ligaments, tendons, joints, and bone, in all varieties and combinations; in fact, this series of pains and painful affections constitutes one of the largest that the medical profession is called upon to deal with.

EXTRACT XI.

ON THE DRAINAGE AREAS OF THE SKULL AND BRAIN.

THE drainage areas of the skull (Figs. 56, 57) may be divided into three, in accordance with the fossal divisions of its base, thus :—the first, or anterior, draining the area extending from the internal surface of the frontal bone to the smaller wings of the sphenoid, and containing the frontal lobes of the brain with their contained lateral ventricles ; the second, or middle, extending from the smaller wings of the sphenoid bone to the insertion, or attachment, of the *tentorium cerebelli* to the petrous processes of the temporal bones and the internal transverse ridges of the occipital bone, and draining the middle and occipital lobes of the brain, with the contained third ventricle, its appended hypophysis, and its superimposed epiphysis, and the third, or posterior, extending from the line of attachment of the *tentorium cerebelli* into the petrous processes of the temporal bones in front to the *torcular Herophili* behind, and draining the cerebellum, or small brain, with the *pons Varolii*, *medulla oblongata*, and fourth ventricle. Each of these areas possesses in its floor drainage facilities for the discharge of surplus cerebrospinal fluid in the shape of openings, or foramina, which, along the outgoing and incoming nerve and blood-vessel structures, allow its free, but guarded, circulation, or outflow.

These areas represent three well-defined basal skull terraces, (Fig. 56) or fossal plateaus, so to speak, on which, as a foundation, the great cerebral textural divisions rest,

shelving downwards from front to back, and each possessing, at its lowest floor level, a system of exits, into which gravitate all the residual materials from the

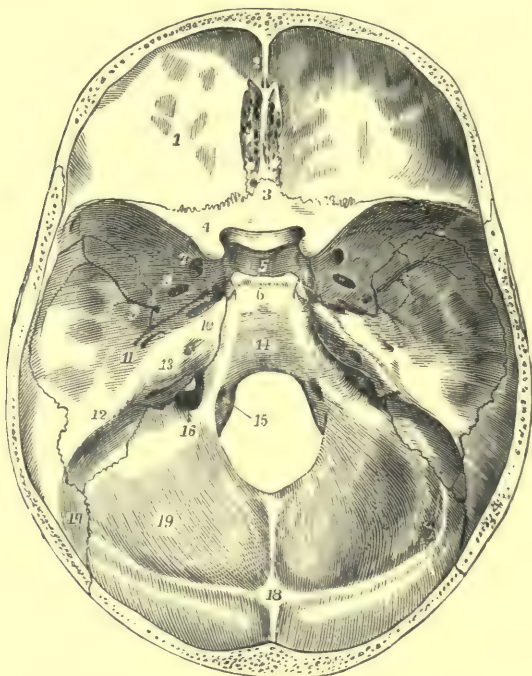


FIG. 56.—INTERNAL BASE OF THE SKULL. (A. T.) $\frac{1}{2}$.

- 1, anterior fossa and roof of the orbit, as formed by the frontal bone; between 2 and 3, the foramen caecum, crista galli and cribriform plate of ethmoid; 3, ethmoidal spine of the sphenoid; 4, lesser wing of sphenoid terminating posteriorly in the anterior clinoid process, inside which is the optic foramen; 5, placed in the pituitary fossa, behind the olivary eminence and transverse groove of the optic commissure; 6, dorsum sellae, terminating in the posterior clinoid processes; 7, foramen rotundum, in front of which, but not seen in the figure, is the sphenoidal fissure; 8, foramen ovale; 9, foramen spinosum; 10, on the petrous bone, near its apex, and to the inside of the hollow occupied by the Gasserian ganglion; in front of this is the foramen lacerum; 11, in front of the eminence of the superior semicircular canal, and behind the hiatus Fallopii; 12, upper border of the petrous, marked by the superior petrosal groove; 13, the posterior surface of the petrous—to the inside, the internal auditory meatus, behind, the scale of bone covering the aqueduct of the vestibule; 14, basilar groove; 15, anterior condylar foramen; 16, jugular foramen; 17, groove of the lateral sinus, behind, the occipital protuberance, and running down from it the internal occipital crest; between 17 and 18, the upper part of the groove of the lateral sinus, between 17 and 16, the lower part; 19, cerebellar fossa.

ventricular cavities and inter-meningeal spaces, through which they percolate, or are driven into, textures without the skull, directly continuous with them, for ultimate disposal. The cribriform foramina of the ethmoid bone, the early

central and lateral foramina of the basi-sphenoid bone, with the foramen magnum of the occipital bone, constitute

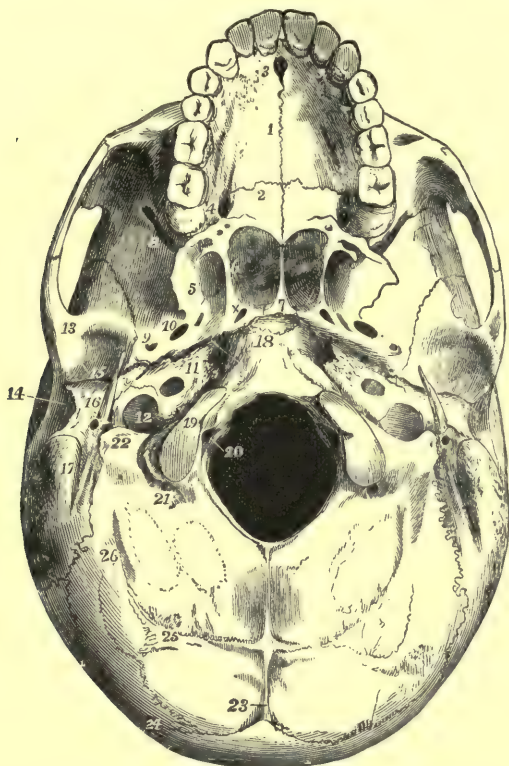


FIG. 57.—EXTERNAL BASE OF THE SKULL SHOWN IN FIGURE 56. (A.T.) $\frac{1}{2}$.

- 1, palate plate of the superior maxillary bone; 2, palate plate of the palate bone; 3, anterior palatine canal; 4, is placed outside the posterior palatine canal, inside the tuberosity of the superior maxilla, and in front of the smaller posterior palatine canals; 5, inner surface of the external pterygoid plate; 6, is placed within the posterior opening of the right nasal fossa on the internal pterygoid plate; 7, vomer; X, posterior opening of the pterygo-palatine canal in front of the foramen lacerum; 8, sphenomaxillary fissure leading into the orbit; 9, foramen spinosum; 10, foramen ovale; 11, placed on the apex of the petrous bone, between the foramen lacerum and the inferior opening of the carotid canal; 12, jugular foramen; 13, articular eminence of the temporal bone; 14, external auditory meatus; 15, glenoid fossa in front of the fissure of Glaser; 16, tympanic plate or posterior part of the glenoid fossa, close to the styloid process, behind which is seen the stylo-mastoid foramen; 17, mastoid process, and to its inside the digastric and occipital grooves; 18, basilar process of the occipital bone, and in front the mark of the still incomplete union with the body of the sphenoid bone; 19, condyle of the occipital bone; 20, is placed in the foramen magnum, and points to the inner opening of the anterior condylar foramen; 21, posterior condylar foramen; 22, jugular process of the occipital bone; 23, external occipital crest running down from the protuberance; 24, superior curved line of the occipital bone; 25, 26, inferior curved line.

the main sewers, so to speak, through which the cerebral lymph circulation obtains a regulated and safeguarded

outflow, and one or all of which are simultaneously, or consecutively, available during the continuance, or existence, of the normal physiological conditions, for the maintenance, or preservation, of the normal intra-cranial pressure, and the obviation of its undue increase, or diminution. Supplementary to these we may include, or claim, the Pacchionian bodies, or extensions of the arachnoid, which traverse, or run through, the inner table of the calvarium, more especially in certain regions of its upper aspect, as completing the tutelary provisions of the great brain drainage structures and mechanisms.

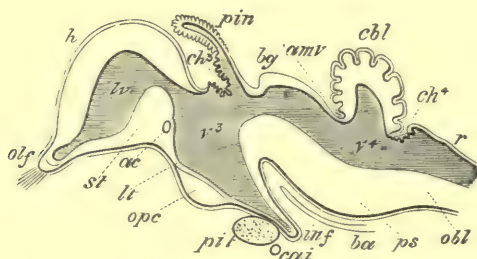


FIG. 58.—OUTLINE OF A LONGITUDINAL SECTION THROUGH THE BRAIN OF A CHICK OF TEN DAYS. (After Mihalkovics.)

h, cerebral hemisphere; *olf*, olfactory lobe and nerve; *st*, corpus striatum; *lv*, lateral ventricle; *ac*, anterior commissure; *lt*, lamina terminalis; *opc*, optic commissure; *pit*, pituitary gland; *inf*, infundibulum; *cai*, internal carotid artery; *v3*, third ventricle; *ch3*, choroid plexus of third ventricle; *pin*, pineal gland; *bg*, corpora bigemina; *amv*, anterior medullary velum; below which two last references are the aqueduct of Sylvius and crura cerebri; *cbl*, cerebellum; *v4*, fourth ventricle; *ba*, basilar artery; *ps*, pons Varolii; *ch4*, choroid plexus of the fourth ventricle; *obl*, medulla oblongata; *r*, roof of fourth ventricle.

The central cavities or ventricles of the brain drain into and through the olfactory tracts, (Figs. 50, 51), bulbs, and nerve extensions, anteriorly, into and through the infundibulum, with its attached pituitary gland, and the pineal gland centrally, and into and through the foramen magnum posteriorly; while the inter-meningeal or peripheral brain spaces empty themselves through the continuous inter-meningeal spaces, which pass out through the various openings in the skull wall along with extensions of the meninges.

In studying this system of drainage of the skull and brain we have been much struck with what seems also to have impressed other observers, without, however, their apparently *guessing* the developmental necessities under-

lying it, viz. the similarity existing between the anterior and posterior, or upper and lower *central lymph exit arrangements* of the central systemic nervous system, i.e. between the infundibulum, pituitary gland, and attached

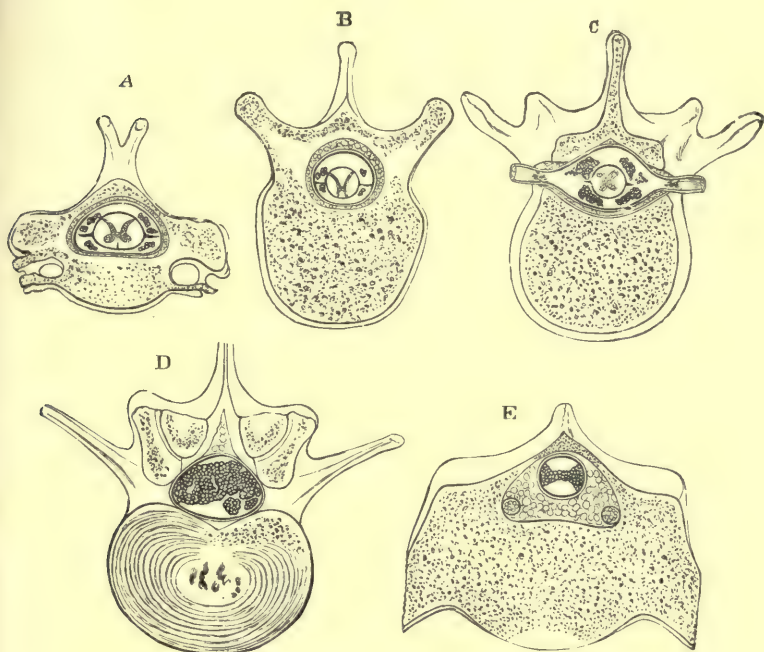


FIG. 59.—SECTIONS SHOWING THE GENERAL RELATIONS OF THE SPINAL CORD TO THE INCLOSING THECA, AND OF THIS TO THE VERTEBRAL CANAL. (Key and Retzius.)

A, through the fifth cervical vertebra; B, through the tenth dorsal vertebra; C, through the first lumbar vertebra and the foramen of exit of the twelfth dorsal nerve-roots; D, through the disk between the second and third lumbar vertebrae; E, through the first sacral vertebra. In A, B, and C, the cord, covered by pia mater, is seen in the centre, with the ligamentum denticulatum attached to it on either side; the nerve-roots on either side form small groups which, since they pass obliquely downwards to their foramina of exit, are cut across; the dura matral sheath is separated by a considerable space from the cord, and by a quantity of loose areolar and fatty tissue from the wall of the vertebral canal. This tissue is in smaller amount in C. D and E are below the termination of the cord, and show sections of the nerve-bundles of the cauda equina within the theca, which is very large in D, but comparatively small in E, the vertebral canal in the latter being largely occupied by adipose tissue. In this are seen the sections of two large veins. The arachnoid is not represented in any of these sections.

excretory mechanisms, anteriorly or centrally, and the *filum terminale*, the coccygeal gland, and related excretory mechanisms posteriorly—the infundibulum *having, in fact, been even called the anterior filum terminale* by some of these observers.

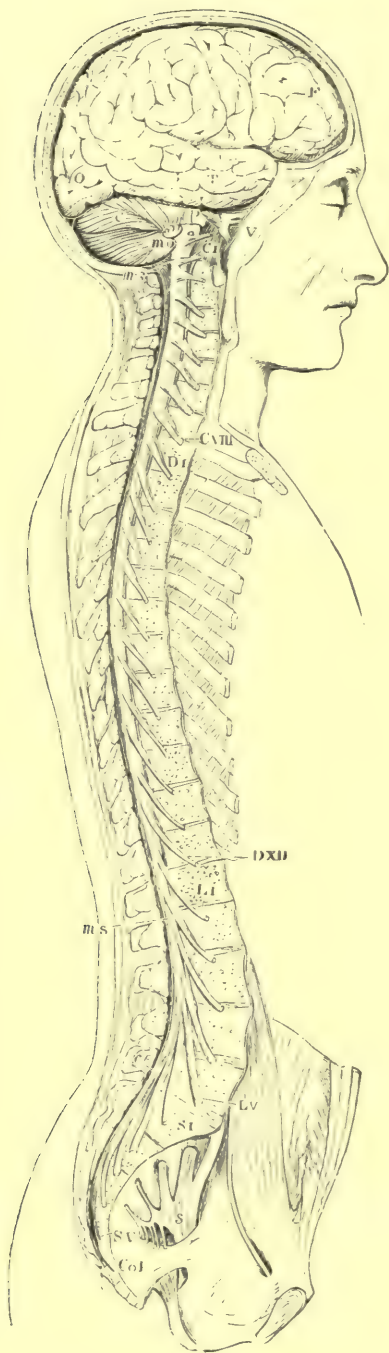


FIG. 60.

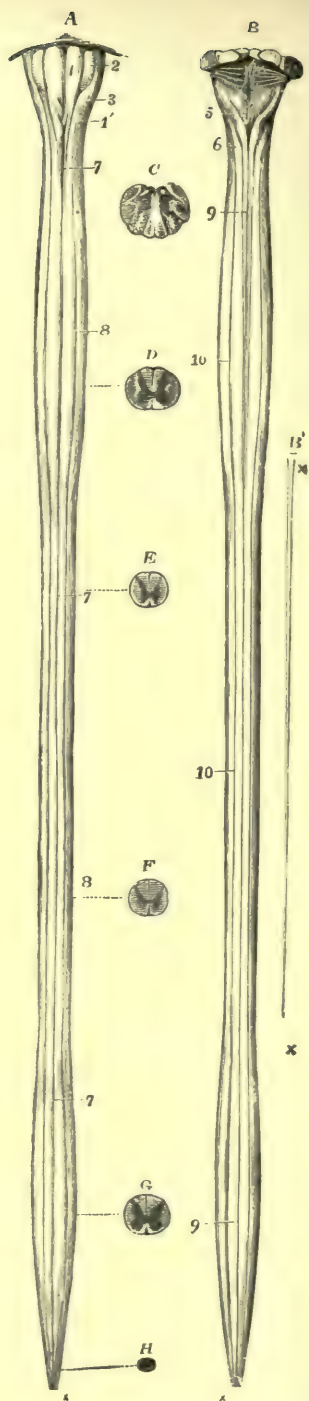


FIG. 61.

This similarity, in our opinion, is not only founded upon, but is the outcome of, the operation of similar, or related, developmental factors in the quasi-obliteration of the continuity of the lumen of the neuro-enteric canal, and in the laying down, in the interpolated metamorphic structures, of a drainage system, by which the separated and differentiated portions of that canal are maintained in *modified* histological continuity, but altered functional rôle. In our observations and studies bearing on this system of drainage we have been much impressed by the histological and physiological sameness involved in the processes of the early embryonic development, separation, and differentiation of the two divisions of the neuro-enteric canal, as well as by the continuance in after life, on somewhat corresponding lines, of some of their common characteristics, structural and functional. Thus the "lymphoid" element is largely in evidence in the textural arrangements of the nasal, pharyngeal, and anal, metamorphic, or

FIG. 60.—VIEW OF THE CEREBRO-SPINAL AXIS. (After Bourguery.) $\frac{1}{2}$.

The right half of the cranium and trunk of the body has been removed by a vertical section; the membranes of the right side of the brain and spinal cord have been cleared away, and the roots and first part of the fifth and ninth cranial nerves, and of all the spinal nerves of the right side, have been dissected out and laid separately on the wall of the skull and on the several vertebrae opposite to the place of their natural exit from the cranio-spinal cavity.

F, T, O, cerebrum; C, cerebellum; P, pons Varolii; *mo*, medulla oblongata; *ms*, *ms*, point to the upper and lower extremities of the spinal marrow; *ce*, on the last lumbar vertebral spine, marks the cauda equina; *v*, the three principal branches of the nervus trigeminus; C I, the sub-occipital or first cervical nerve; C VIII, the eighth or lower cervical nerve; D I, the first dorsal nerve; D XII, the last dorsal; L I, the first lumbar nerve; L V, the last lumbar; S I, the first sacral nerve; S V, the fifth; Co I, the coccygeal nerve; *s*, the left sacral plexus.¹

¹ The relation between the bodies and spines of the vertebrae and the places of attachment of the nerve-roots to the cord is also illustrated by this figure. For more detailed information on this point the reader may consult Gowers, *The Diagnosis of Diseases of the Spinal Cord*, 1880.

FIG. 61.—ANTERIOR AND POSTERIOR VIEWS OF THE MEDULLA OBLONGATA AND SPINAL CORD WITH SECTIONS. (Allen Thomson.) $\frac{1}{2}$.

The cord has been divested of its membranes and of the roots of the nerves. A is an anterior, B a posterior view. In these figures the filiform prolongation, represented separately in B', has been removed; C shows a transverse section through the middle of the medulla oblongata; D, a section through the middle of the cervical enlargement of the cord; E, through the upper dorsal region; F, through the lower; G, through the middle of the lumbar enlargement; and H, near the lower end of the conus medullaris.

1 to 6 refer to parts of the medulla oblongata; the remaining numbers to parts of the spinal cord.

1, pyramids; 1', their decussation; 2, olivary bodies; 3, lateral columns; 4, posterior surface of the medulla oblongata; 4', calamus scriptorius; 5, funiculus gracilis; 6, posterior lateral columns passing to the side; 7, 7, anterior median fissure of the spinal cord; 8, 8, antero-lateral impression corresponding to the attachments of the anterior nerve roots; 9, 9, posterior median fissure; 10, 10, postero-lateral groove; X, tapering extremity of the cord; X, X, in B', filum terminale.

interpolated tissues, as shown by the common presence of "*excretory*" *material* and *function*, which determines consequent likeness in such pathological conditions as adenoids of the nasal passages, enlargements of the pharyngeal mucosa, and hæmorrhoidal developments of the post-rectal and anal parts. All which seems to us to prove, what we may regard as axiomatic, that the operation of like developmental factors on like, or intimately related, organic materials results in the evolvment of like, or very similar, developmental products, or structures, and hence the great sameness which characterises the early condition of the anteriorly united, and posteriorly separated, parts of the neuro-enteric canal as to their textural conditions and functional rôle ; hence, also the occurrence of such a thing as the retention of a once common embryonic function, as a *still operative survival*, in after life, such as is seen in the secretion, or excretion, of peptone by the pio-meningeal textures of the cerebrum and cord.

These drainage areas are determined by anatomical and histological necessities, due to the topographical disposition and relative position of the textural divisions of the central nervous system, and the system of drainage is determined by the prevailing nature—as to consistence—of the drainage material, and the outlet conditions best available and most favourable to the operation of the existent local physiological hydrostatics and dynamics ; the principal illustration of which we might adduce as, what may be called, the "*cloaca major*" of the central drainage system of the cerebrum, or the infundibulo-pituitary apparatus, which receives the residual and waste products of the great body of cerebral material emanating from the mid- and hind-brain, and excretes it on the surface of that continually open, generally moist, and *constantly swept*, glosso-pharyngeal cavity, or highway, situated at the commencement of the gastro-intestinal or alimentary canal, where it becomes, no doubt, a factor in the process of the functional work of that canal of no mean importance, as becomes, at once, apparent when any local pharyngeal-oral obstruction to its physiological fulfilment takes place.

The great cranial outlet, the *foramen magnum*, allows of the free outflow of surplus cerebro-cerebellar lymph

into the great inter-meningeal cavities, or channels, surrounding the spinal cord (Figs. 59, 60), as well as of what escapes from the fourth ventricle by way of the central canal, a truly considerable, or even large, quantity, but ideally adapted, through inter-meningeal distribution and attachments, to provide a fluid encasement and yielding surrounding medium, in which the spinal cord is floated without the possibility of contact with its skeletal framework—the *ligamentum dentatum* acting as a dual valve against sudden, or large, lateral displacement, while maintaining free longitudinal movement or circulation.

Under these circumstances over-pressure is relieved, when necessary, both in brain and cord, through the cephalic and spinal nerve continuations of the sub-arachnoid and sub-dural spaces, by calls being made on both the afferent and efferent systemic nervatures, whereby the skin and muscles are made to provide the required outlet facilities, or excretory agencies.

EXTRACT XII. A.

ON THE GENERAL BEARINGS, AND RÔLE, OF THE HÆMAL LYMPH AND THE CEREBRO-SPINAL FLUID.

THAT the hæmal lymph, or fluid, is the earliest differentiated fluid in the economy of the fecundated ovum, or in the pre-existent germ and sperm cell elements, as well as in the resultant, or sequential, embryo, is abundantly obvious as a fundamental embryonic truth, and that it continues, in conjunction with the more lately elaborated cerebro-spinal lymph, to play a most important part in the economy of the growing organism, is equally obvious to the anatomist and physiologist, while, as the life of that organism lengthens out into even the senile stage, it continues to be observed by the clinician to exercise a profound influence on its progress in relation to its functional work, its freedom from the attacks, and its power of resistance, of pathogenic influences and agencies.

Thus, in the embryo, we see the early, or nascent, structures and organs evolve themselves within and inter-penetrated by this hæmal lymph fluid, and that it is gradually displaced by the accumulating neural lymph, as the various structures increase in consistence and volume, and become differentiated into anatomical and physiological systems and entities, until the arrival of the period of post-natal, or independent, existence finds the neural lymph, in turn, relegated to the central spaces of the brain and cord and to the peripheral, or inter-meningeal, and the inter-neurilemmar spaces of brain, cord, and nerves respectively, and to the dually innervated structures generally, where it, the neural lymph, continues its gradually restricted rôle of mechanical

and physiological work as an indispensable fluid in the economy of life.

The alteration in its disposal, within, and without, the systemic nervous system, as that system is affected by age, shows its adaptability, in functional purpose, to every phase, temporary and permanent, of the life history, as well as to the "thousand and one" minute changes, which characterise the daily experience of every human organism.

In its first production and disposal the lymph generally may be likened to a culture medium, in which the growth of the ovum, with the succeeding embryonal structural evolutions, take place in a region of secured developmental calm and freedom from external disturbance, and to a great extent shut off from maternal influences—"maternal impressions" notwithstanding—while, in its later embryonic disposal, the neural lymph becomes "gathered up," so to speak, within the neuro-enteric canal, and projected, or diverted, along the many nervine channels, as they become developed from the ectodermal into the meso- and hypodermal areas. During these developmental phases, what is a mere, but great, cerebro-spinal fluid cistern, or canal system, becomes encroached upon by a gradual process of neuro-mural thickening, and consequent general narrowing, of its central lumen, until an organised series of spaces and tubes alone is left to carry on the cerebro-spinal lymph circulation in post-natal conditions.

It will, consequently, be easily evident that the immediately post-natal cerebro-spinal circulatory facilities must mark their maximum, and that a process of solid material encroachment from neuro-mural thickening and passive accumulation of structural debris, or detritus, and interference with excretional mechanisms, must ensue, in proportion to the advancement of life generally, and with the existence of environments inimical to health particularly. It will, therefore, likewise become evident that these natural occurrences, as they develop themselves physiologically, may become pathogenic, and that rational medicine must busy itself in the discovery of means to obviate them, or to neutralise their incidence.

The functional rôle of the cerebro-spinal fluid, as here and elsewhere outlined, is a largely passive and mechanical

one, but also, as we elsewhere contend, an excretory one. We want, therefore, to be consistent in our estimate of its true place in the economy of neural physiology, *to disclaim for it the nutritive function* which it has been sometimes credited with serving, inasmuch as we contend that the nutritive material which it is supposed to convey to the nervous textures is, *during its formation, deposited from the blood, as glia*, in the neuroglial feltage, where it is taken up by the dendritic processes of the nerve cells, and converted into nerve plasma within each cell, according to its individual and systemic requirements. The yielding of an elastic support and bufferage to the structures which it encloses may, therefore, be described as its main mechanical office, together with the maintenance of the proper proportion of moisture in the inter-spaces of the brain, cord, and nerves to secure the requisite plasticity of the true nervine elements and the needful excretional circulation from within these elements. Along with its excretional disposal of effete nervine material, we would also include the "excretional" disposal, or radiation, of surplus central caloric and the maintenance of the normal body temperature, a function which the universality of its presence, circulation throughout, and exits from the body render possible and functionally easy of accomplishment.

As illustrative of the truth of the last-mentioned functional work of the cerebro-spinal fluid, we would only call attention to its almost constant disturbance in all diseased conditions in which rise and fall of body temperature take place, the main reason for such rise and fall being the disturbance of cerebro-spinal lymph circulation and excretion and consequent interference with heat radiation.

The cerebro-spinal fluid, as a culture medium, and viewed in relationship to the infective invasion, incubation, and distribution of bacterial organisms and disease germs, may be regarded as the most ideally perfect to be found within the whole body, on account of its intrinsic qualities, histological environment, comparative isolation and means of graduated escape available for shedding or emigration; it will, therefore, we think, be found, as research progresses, that a very much larger number of pathogenic bacterial organisms owe their existence and propagation to this fact

than etiologists have hitherto believed, and that clinicians will have, consequently, to alter their diagnosis and adapt their treatment accordingly.

Zymosis, or bacterial proliferation, may be confined to the cerebro-spinal fluid, and may begin and end there, but often it is attended by bacterial attack of its containing vasculature and organic environment, when meningeo-neurilemmar complications arise, or by neuronal implication, when diseases of the proper nerve elements develop the symptoms proper to disordered nerve substance and function, as may be witnessed in such diseases as tetanus, hydrophobia, trypanosomiasis, "rheumatism of the brain," "general paralysis of the insane," and many other familiar central nervine affections. In such of these diseases, where the neurons are attacked by the individual, or specific bacteria belonging to a particular disease, the characteristic symptoms of the particular disease then become manifest, as its bacterial organisms grow and propagate themselves according to their individual manner, whether they be benign or malign—and in such cases they are generally the latter—through the textures attacked being of such a highly essential character, both in material and function, in the economy of life and cerebration. In the neuronophagic processes indulged in by the individual bacterial genus a manner of procedure and histological effect are developed whereby, in many cases, the microscope can distinguish the culprit and indicate the disease for the production of which it is, by its specific action, pathologically responsible. Thus, it becomes abundantly evident that a wide field for the bacteriologist and clinician is here coming into view, the exploration of which must yield abundant information, both of a scientific, and practical, kind, for the guidance of the future practitioner of medicine and the satisfaction of the *amour propre* of pure science.

The cerebro-spinal fluid thus becomes an incubative medium and organic vehicular element of the greatest moment to the scientist and clinician alike, inasmuch as it possesses attributes the appraisalment of which will require the exercise both of their intelligence and the therapeutic use of their united deductive and practical efforts. Moreover, according to that appraisalment and practical use must

follow the success of future medical and surgical procedure in a domain of remedial and ameliorative effort peculiarly required in, and applicable to, the abounding neural wants of present-day civilisation, with its almost unique material and dynamic needs, which almost daily increase with its quickening advancement and the increased competitive strain, national and individual.

EXTRACT XII. B.

THE RÔLE OF THE CEREBRO-SPINAL FLUID AND LYMPH PROPER.

THE rôle of the cerebro-spinal fluid, or lymph, may, in conclusion, be summarised, or regarded, as that of a mechanical support and buffer, a medium for the floating of the intra-cerebro-spinal systemic blood vasculature and the proper systemic neural elements, as well as a vehicle for the reception and removal of intra-neural disjecta, or debris, and the provider of an aseptic inter-penetrating and surrounding fluid material for the maintenance of intra-neural hygiene, an afforder of an insulating element for the production, reception, and storage of nervine energy by the means of a stratum of peripheral non-conducting, but neuro-pervious, liquid throughout the entire nervous system, permeable from without by sensory nervine stimuli, and communicative, from within, of motor nervine impulses throughout the confines of the muscle areas, voluntary and involuntary, systemic and sympathetic.

Such a bald recapitulation of some of the salient functions of the cerebro-spinal fluid reveals the truth that we have in it a neurally omnipresent element second in importance to none of the non-nervous constituents of, or connected with, the nervous system, and an element whose physiological importance, in many other respects as well, should ensure a whole-hearted study of it, in order that its importance in a practical respect should be made fully available to the practisers of the healing art, and for its intrinsic value to the exponents of pure science, and the lovers of truth for its own sake.

Moreover, this fluid represents the *primordial fluid* in which the whole developmental events, constituting the "life history" of organic nature in all its phases, is wrought out, and the medium which gives or affords currency to the whole chemico-physiological elements and processes engaged in the great work of evolution of living forms, and the peopling of our earth from its dead matter; it is, therefore, a fluid whose imitation, or reproduction, by scientific technique may enable us, when a human, or other, life is suffering from its exhaustion or over-abundance, to lengthen out its otherwise unexhausted vital resources, and to round off in full proportion the story of its "completed life," as we see, for example, in the use of "normal saline" in hæmorrhagic crises, and syncopal attacks, or of lumbar puncture in cerebro-spinal meningitis. Further, it forms the basis of all the actively organic, or formative, fluids throughout the body, and passes from one form of structural and visceral physiological fluid combination, or condition, to another, as the local and general exigencies of inter- and intra-organic circulation necessitate and determine; hence it is the circulatory medium for all material interchange, chemical and physiological, and therefore, pathological, and requires to be studied locally and in all its continuity of circulatory disposal and functional sequence, ere we can hope to discover its full significance and importance, and obtain its full practical advantages. Therefore, to follow it thus is to follow the organic disposal of the entire ingesta, from their imbibition to their excretion as effete materials, or until they become egesta, and thus to traverse the whole field of biological integration and disintegration, or, in other words, the entire area of physiological activity and organic evolution. We, consequently, would advise that this aspect of the subject should be viewed whenever we attempt to take a broad or even a "bird's eye" view of the bearing of physiological knowledge on the progress of clinical medicine and surgery.

In another respect it can be followed with great advantage along the paths by which the cavities and inter-spaces of the body, structural, visceral, and histological, are kept occupied, and the physiological balance of circulation and

nutrition maintained, as, for example, along the paths of the great systemic circulations into the cavities, great and small, where the serous and lymphoid fluids repose, or are stored ; and, out of these, into the organs and channels of excretion, where the final processes of chemical and physiological change are undergone, and the vitally exhausted residual products finally evacuated as absolutely effete and adynamic.

The inter- and intra-structural cavities and channels thus occupied render great mechanical services in the obviation of structural and inter-structural voids, the bolstering of actively functional textures, and the ballooning of collapsible tissue elements, while at the same time affording nutritional facilities for the circulation and interchange of chemico-physiological elements in the processes of repair and decay. The spaces and inter-spaces thus occupied vary in size from the atomic and the cellular to that of the largest anatomical cavity, and represent the great and small fluid areas surrounding the histological elements of the entire body ; and, therefore, it becomes necessary to recognise the great physiological fact, that there is no essential material difference in the chemical and physical character of the occupying fluids, save in the added or subtracted amounts of integrative and disintegrative materials respectively, and that thus there is, and can be, but one foundation fluid, the lymph, occupying the entire system and effecting all the changes concerned in the phenomena of its organic, or vegetative, life.

In thus viewing the subject of the omnipresence of a fundamentally identical fluid element throughout the body from which the nutritional elements are extracted, and into which are returned in a physiologically secured manner, for final disposal, the waste products of functional activity, we must regard its chemical and physiological varieties as due to the textural and visceral contributions, for special physiological purposes and chemical desiderata within the great vital laboratory constituting the living and acting body, and subserving the purposes of its vital chemistry. Consequently, the acts of alimentary absorption, sanguineous circulation, nutrition, lymph circulation and excretion, but illustrate the existence of varieties of this

fluid, and show, while chemically dissimilar in composition, that they are identical in physiological operation or manner of working, and that they make up among them a great cycle of chemico-physiological activities through a material or physical continuity of physiological fluidities or secretions—these latter ranging from, or consisting of, the chyle, the blood, the lymph, and the special organic fluids, such as are poured into the alimentary canal, concluding with the exhausted and adynamic residual materials eliminated from the various excretory organs as alvine, renal, and cutaneous evacuations. It is needless to point out that water necessarily constitutes the fluid basis of every variety of physiological liquid, and forms the vehicle of conveyance and the medium in which all the chemico-physiological phenomena of tissue integration and disintegration take place; it is, therefore, the *sine qua non* of nutrition in all its phases, and the element most essential in all varieties of alimentation and dietetic formularies.

EXTRACT XIII.

SUMMARY OF STUDIES ON CIRCULATION.

“All things flow, and nothing is at rest.”

“All things are in a state of flux.”

THE author of these words was the Greek philosopher Heraclitus, who lived about 500 B.C. The *law* enunciated, and the *generalisation* accomplished, in them necessarily presuppose the possession, by their author, of a knowledge of “first principles,” derived from a wide range of observation of natural phenomena, and a grasp of their significance which can scarcely be surpassed, or paralleled in the whole history of, at any rate, ancient natural science. In the terseness of their expression, and arrangement, and in the depth of their meaning, we see one of the most successful attempts to reach the *bed-rock* of *natural truth*, as we may call it, and to lay *for ever* on it a foundation which could bear the weight of the most gigantic superstructure, and which could yield security for the exercise of the best efforts of the votaries of science, and make a worthy repository for their contributions to the sum of human knowledge.

The principal truth conveyed by them is, that matter, in its widest, as well as, most restricted sense, in mass, and in molecule, is ever moving, that a state of flux and re-flux characterises the behaviour of the material universe, and that no possible exception is to be perceived within the sphere, sidereal, or terrestrial, of its application.

EXTRACT XIV.

ON THE PHYSICAL LAW, OR PROPERTY, OF MATTER, KNOWN AS INERTIA.

THE law, or property, of inertia, as applied in physics, has long been accepted as axiomatic, and as universally operative, throughout the world of matter, and that it is *relatively* so we are not prepared to dispute, more than that it should be applied only to matter in motion, because matter at rest must be regarded as a *physical impossibility*, even in the most perfectly-conducted vacuum experiment, where its apparent rest, is owing merely to a temporary arrest or rather slowing, of the rate of its continual and universal movement. The temporary arrest, or slowing, of the rate of motion by such experiments as above mentioned can only be regarded as a "toy stoppage," which is annulled by the frictional influence of "passing events," and the disintegrating effects of the "hands of time," as they reduce to dust the most durable material that can be converted into a vacuum vessel, as it passes through space at planet speed. Verily it may, and must, be said, that there is no "abiding place" in nature, and that there is no exception to the truth of that part of the law of inertia which is alone operative in the physics of the material universe, that matter in motion will continue for ever in motion, and that there can be no possibility of its *absolute arrest*. The *apparent* exceptions to this aspect of the law of inertia of matter are *only* apparent and make the necessity of accepting the truth of the law, as thus modified, absolute, and undeniable. Moreover, all the sciences, so far as we have been able to appreciate their demands, recognise, and

call for, but the *one reading* of this great law, in their attempts to reach the truth as it is to be found impressed in legible characters on the "book of nature"; their appreciation of the affirmative aspect of the law—if we may be allowed the expression—is universal, their regard for the negative side of the law—in like manner—places in bold relief, that they tacitly regard it as a negligible quantity, a scientific curiosity, or a "survival" of the *not fittest*. We, therefore, once more see, even here, where scientific beliefs, like coal, have been crystallised into diamonds, that negative, or neutral, elements, have become attached to them which call for removal, that their full lustre may be revealed, and their true value appraised, before they become the prized and permanent possessions, of earnest searchers after truth.

We, moreover, claim that the law of inertia, as thus understood, should be regarded as the most *far reaching* of the physical examples of circulation, and that by it matter is affected, and directed, in its movements in molecule and in mass, in both its organic and inorganic, regions; in its forms visible to the naked eye, as well as in those which can only be revealed by the aid of microscope, and telescope; and by inference, those others, lying beyond our ken, which appeal to our intelligence only as articles of *scientific faith*. Again, therefore, we feel ourselves constrained to repeat: *circulatio circulationum omnia circulatio*, and that—instead of banishing "perpetual motion" to the limbo of the unknowable—we must regard it as the *very pivot* on which the phenomena of the universe revolve, and the foundation on which they may be said to *rest*, to use a word which is strangely contrary in meaning, and a complete contrast to the entire problem under discussion, but nevertheless embodying a fragment of the truth on which alone belief itself, when sifted from all untruth, may find a resting-place, and a calm repose after its vicissitudes of "change and decay," of strength, and weakness, of age, and rejuvenescence, of rejection, and acceptance, negation, and affirmation.

The teaching of modern physics is, but a continuation, and illustration, of this great truth in its wider, more elaborated, finished, and cultured, aspects.

One of these aspects is concerned with its bearings on the subject of "circulation" generally, but more especially of "circulation," as it is to be met with, and illustrated, in the economy of animal, and vegetable, life.

This subject is now well worn, and has done great and good work in clearing up many of the secrets of animated nature, and, we think, it has still much to do in the same field, ere we can afford to lay it aside as an instrument which has ceased to be of use to the exponents of modern biological science. Personally, we think that a wider and fuller use, may still be made of it, in the study of animal and vegetable, or biological, statics, and dynamics, with a sure prospect of its being able to advance the conquest of research into some of the mysterious regions of this field, and others, that lie immediately ahead of the *pioneers* of natural science. As proving our confidence in this sanguine forecast, we are tempted to permit ourselves, at the outset of our supplementary remarks, rather than at their close, to crystallise our belief in the truth of what we say, as we have done before, by using a form of words after the manner of the illustrious Greek philosopher whom we have quoted, to the following effect, and in the following order, viz.: *circulatio circulationum omnia circulatio.*

The truth of these words, and of this thesis of varieties, we shall now endeavour to make manifest, and, in doing so, we shall confine ourselves, more especially, to that aspect of the subject which finds its illustration in the animal, and more especially, in the human economy. Here we find that the principle of circulation is universally operative, in all the processes which we denominate vital, and that by, and through, it, the manifold operations of building up, and taking down, of taking down, and building up, of ministering to the wants of conscious being, and, finally, of effecting the resolution of the component corporeal parts into their inorganic elements.

In attempting to accomplish this large, and self-imposed, task, we must confess our inability adequately to compass it, or in any appreciable degree to exhaust it; but we flatter ourselves that we may, in our restricted efforts, be at least, "aiding, and abetting," others in carrying

on the work of investigation of the large collection of already recorded observations and experimental data, lying ready to hand and capable of affording what is required for absolute proof, and general acceptance, in the deduction, and formulation, of its theoretical "manners and methods," while, to some extent, assisting the elaboration of its practical benefits, in their application to the wants of everyday medicine, and surgery.

The recording of the order and sequence of the various parts of this attempt at somewhat widening the boundaries of knowledge must, to a great extent, be left in the meantime irregular and arbitrary inasmuch as the materials of the record represent the everyday mental collections of a lifetime, together with roughly assorted scientific data which have not been arranged, or elaborated, primarily, with a view to publication, but rather with the view of affording a means, whereby we could from time to time take stock of the "manner, and matter," of our daily thoughts, and beliefs, amid the work, and worry, of our everyday life.

Friends having advised the publication of these efforts at scientific work, recurring and therefore, necessarily scattered, and, for the most part, the carelessly written records of *broken studies*, their advice has at last been taken, in the hope that some parts, or fragments, of these studies, at least, might resist the crucial tests of criticism. We, moreover, feel constrained to submit ourselves to the tests dictated by the requirements of special knowledge, even in this specially unprepared fashion, believing that it is better to know what is true in them, and wishing what is untrue to be sifted out of them, so that, if there be any grains of truth left, they can be made available for what they are worth, both, as additions to abstract science, "pure and simple," and as, not unneeded, additions to the beneficent agencies of applied science.

Chronological sequence of production will, therefore, to some extent, interfere with that strict continuity of treatment and detail of subject which is so essential for the obtaining of a complete "grasp" of the meaning and purport of what we want to convey; and this may lead to faults, both of omission and commission, and to the occurrence both of gaps, and repetitions.

With these introductory observations, we now proceed to summarise, and to place the results of our observations, and reflections, with all their original and acquired imperfections, before our contemporaries, apologising for the omission of mention of our sources of knowledge, a work which we have found impossible, inasmuch as, they, the subjects of our remarks, consist of material first gathered from the lips of revered teachers, and of colleagues in the work of life, from information derived from text-books, and accessible works of authority, from articles scattered up and down the serial literature, and publications, of the time, and from independent, and personal sources, presenting themselves during the course of professional life and work.

Returning from this introductory digression, we shall resume the discussion of the subject of "circulation." We had, to some extent, pursued the subject with a view to obtaining a firmer grasp of it in that department which relates to the movement, or circulation, of plastic, or more or less fluid, materials, within more or less well-defined vessels and inter-spaces, such as are met with both in animal and vegetable structures. We shall now, therefore, again take up in its deeper, and so to speak, underlying aspects, more especially as related to such subjects as nutrition, assimilation, disintegration, and excretion, processes which largely make up the problems of life and "organic activity," the cessation of which constitutes death.

Circulation, in its more usual biological aspects, is characterised by *forward* movement of material, or matter, in contrast to *backward* movement, and is due to the operation of forces acting both from before and from behind, as well as, it may be, to latent, or intrinsic, forces acting from within. That being so, we perceive that *nutrition* is made possible only through that forward, or onward, movement, of the nutritive plasma propelled and regulated, by these modes of force, in virtue of the continued, and, in normal vital conditions, the regular replacement of used up, disintegrated, or effete, matter, by fresh, or nutritive matter; which process necessitates the continuous onward, as distinguished from the backward, movement

of the matter in question. In this process we see *concurrently* in operation modes of force which we may designate, mechanical, chemical, and physiological, or vital, the result being the maintenance of the materio-dynamic equipoise whereby the continuance of life is secured. This process, moreover, is one and the same, in its mode of operation, from that instant when the life of the organism takes its origin, in the primary vital spermo-germ arrangement of its primordial atoms, until the conditions of life no longer permit of its continuance. In this process, or, we had almost said, procession, one atom, or molecule, of matter, follows another in regular order; so that when the first has become "worn" out in the process, the next in the succession takes its place, with the ordered continuity of unending circulation, or so long as the required vital conditions continue in existence.

All this necessitates the *constant onward* movement of the circulated matter, and does *not* permit of its *return*, hence we must regard the processes alluded to as being conducted on these lines, and we must be prepared to see in our experimental investigation and study of them, that "sequence of events" which must inevitably flow from the practical working, or operation, of such physiological factors. We must, therefore, from this circulatory sequence and onward movement, also recognise *the fact* that no *self-pollution*, or *autotoxis*, can be permitted, *if* the operations involved are effected perfectly and that physiological health, if they be so effected, must follow with unerring certainty.

In other words, we see, in the operation of these processes on the lines which we have attempted to explain, that nature does not permit, in her untrammelled condition, the pollution of the nutritive material which she is conveying to the living and working structures of the body, by the effete materials resulting from the living and working condition, of that body; but, on the contrary, that she provides that these latter, the effete, must be "*moved on*," or *onwards*, by her vital police, or safeguards, before she gives up the former, or nutritive. In this way *only* is it possible for the dire results of autotoxis to be averted, and the condition of health to be maintained.

Hence we find that the processes of integration and disintegration balance each other, in the highest and best states of health; the body weight being thus regularly and steadily maintained amid all the disturbances of everyday life.

In any and all departures from the normal level of good health we may expect to find an interruption in the regularity of the processes, and a corresponding interference with the continuity of the conditions on which that health depends. It will, therefore, under such circumstances, be of the greatest value to us as the conservers and restorers of health, if we bear this in mind, and do our best to discover where, in the circulatory chain, the first indication of strain is observable, in order to be able scientifically to begin and continue our treatment, preventive, palliative, and curative.

For example, if we analyse the "sequence of events" to be observed in the course of some well-defined disease, or morbid entity, we shall perceive the relevancy of, and the necessity for, the use of this advice. Diseases, therefore, such as a "common cold," or influenza, will afford good examples for consideration on these lines, and they will be found "dealt with" in the accompanying pages.

Hæmal circulation carried on through elaborately constructed vessels and by the operation of well-defined forces is operative up to that point in the human body, where tissue metabolism begins, and where the cerebro-spinal blood circulation ends by depositing its nutritive materials in the neuroglial matrix. At the latter point begins another circulation, or system of circulations purely nervine, or neural, and for the most part confined within the precincts of the systemic nervous system, and its containing membranes. This circulation, the systemic nervine, is *sui generis*, or, at any rate, very different from the circulations which precede it, inasmuch as the textures composing its circulatory apparatus are quite different, as well as the fluids circulated.

The pabulum on which the nervous system is supported, and from which it extracts its nourishment, is represented by the amorphous and faintly organised material deposited amid the fibro-cellular meshes of the neuroglial,

basal, organised texture, and is extracted from that situation by the dendrons of the nerve cells, or neurons, and conveyed to the substance of the nerve structures proper of these neurons, viz. to the cell body with its proper plasmic contents, the nucleus with its special contents, and the innermost neuronal structure, and the nucleolus with its *most* special contents. The nerve cell contents and the nuclear substance being continuous, respectively, with the white substance of Schwann, and the axis cylinder substance of the nerve fibre, initiate and continue other two circulations, represented by these two substances, along each axonal process, or axon; the two substances being fluid, or plastic, enough, to allow of more or less freedom of onward movement, or circulation.

These two central circulations are carried on through, or along, continuous sheaths, or cases, enclosed in a neurilemma composed of layer after layer of dense fibrous tissue containing, within well-defined limits, inter-spaces occupied by cerebro-spinal, or neural, lymph, as distinguished from hæmal lymph. These inter-neurilemmar spaces, with their neural lymph contents, represent at least other two circulations, continuous with, and from, the sub-arachnoid and sub-dural spaces, respectively. Thus, along every afferent, and efferent, nerve fibre, from its origin to its terminal distribution, we have a series of at least four separate and individual circulations simultaneously in operation and requiring for their maintenance an unbroken continuity of tubes and an unfailing supply of fluids, and colloid materials, of appropriate consistence, and physiological quality. An axonal nerve fibre is, thus, a compound of at least four tubes circulating fluids and substances of different consistence, and qualities, along its intra-spaces, each circulation differing from the other according to the consistence of its material and the freedom from obstacles to its onward progress, the two inner being necessarily slow, but the two outer necessarily relatively quick.

The circulations here outlined are carried on mainly towards a free terminal surface, with the exception of

that of the motor nerves, and it must necessarily follow that the substances circulated have to find a means of distal outlet, as backward progress, at least of the two inner, is safeguarded, by appropriate means elsewhere described.

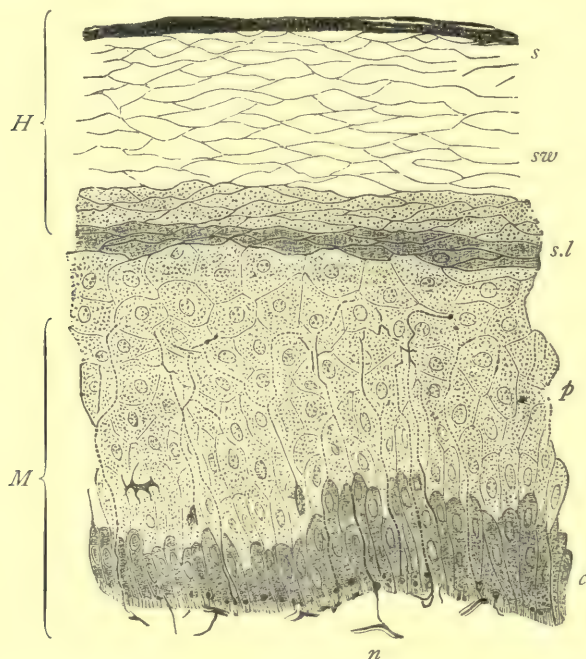


FIG. 62.—SECTION OF EPIDERMIS FROM THE HUMAN HAND. Highly magnified. (Ranvier.)

H, horny layer, consisting of *s*, superficial horny scales: *sw*, swollen-out horny cells; *s.l.*, stratum lucidum; *M*, rete mucosum or Malpighian layer, consisting of *p*, prickle-cells, several rows deep; and *c*, elongated cells forming a single stratum near the corium. The granular cells of Langerhans, which lie just below the stratum lucidum, are not shown, *n*, part of a plexus of nerve-fibres in the superficial layer of the cutis vera. From this plexus, fine varicose nerve-fibrils may be traced passing up between the cells of the Malpighian layer.

Where then are we to look for the means of their final disposal when they have become effete, and no longer capable of retention within the body, without the danger of pathogenesis? The disposal of the neural lymph, or the fluid, circulated by the two outer tubes has been traced in some detail to the sweat glands (Fig. 15), and to excretion through the skin, and into the sarcolemmar sheaths of the muscle fibres. Where then

can the medullary, or white, substance of Schwann, be traced to? and where can the substance of the axis cylinder be evacuated? An answer to these last two questions seems to us to be almost impossible, but nevertheless, we think that the importance of the subject demands that we should do our utmost to trace its progress, until either failure, or success, follows.

It is said that the white substance of Schwann ceases to exist at a point some little distance from the nerve terminals, and, if this be so, we must be prepared to look for its elimination somewhere *before the final*

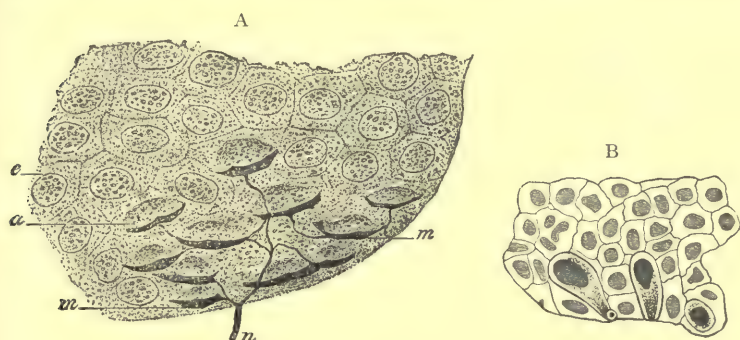


FIG. 63.—A, TWO TACTILE CELLS IN THE DEEPER PART OF THE HUMAN EPIDERMIS. (Merkel.) B, ENDING OF NERVES IN TACTILE DISCS IN THE PIG'S SNOUT. (Ranvier.)

n, nerve-fibre; *m*, terminal menisci or tactile disks; *e*, ordinary epithelium-cell; *a*, altered epithelium-cell, to which the meniscus is applied.

distribution of these terminals. In doing so, however, we *fail* to find any solution of continuity of its containing membrane and, consequently, we must believe that it finds its way out of its containing membrane at the extremities of the nerve terminals, and so empties them, that accounting for the above statement: this, we think, it does amid, and as, the epidermal cells, and keratinous debris, forming the cuticular layers overlying the true skin; indeed, it might be said, without overstretching the "scientific imagination," to *lend itself to the formation of these layers*, and to be *finally shed as epidermal scales* (Fig. 62), with the overlying and interpenetrating horny matrix of keratinous, and connecting, or cementing, material. To this *goal* also may be traced

its containing membrane, and perhaps to the sebaceous glands, we may trace some of these materials, as well as, it may be, the final disposal of the substance composing the axis cylinder of the nerve fibrils with the broken-down constituents of its containing tube, or wall.

The ubiquitous structures represented by the epidermal covering of the cutaneous envelope, the epithelial and endothelial linings of the hollow spaces of the body, constitute the "scene," and afford the "theatre," wherein the ultimate disposal of the materials used up by nervine activity is effected, and where the separation and excretion of the effete and toxic residuum of these materials are carried out.

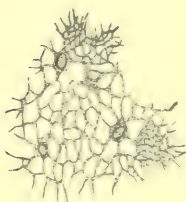


FIG. 64.—PART OF THE RETICULUM FROM THE SPINAL CORD. (Kölliker.) Magnified 350 diameters.

The process of separation, and excretion, may be accomplished through the circulatory agencies belonging to the nervous system itself, and, it may be, also by the aid of other agencies, emanating from, and belonging to, the hæmal system. Thus, there may be a *dual* security provided for the

maintenance of cutaneous perspiration, and transpiration, resulting from the co-existence of a nervine, and hæmal, sudoriferous feeding mechanism, connected with the sweat glands, in virtue of which a state of cutaneous circulatory equilibrium is made possible, and temperature evenly sustained; sweating may, therefore, be due to one, or both, of these sources of supply acting alone, or simultaneously, and, accordingly, the sweat may somewhat alter in character and composition according to which of the sources is the more active for the time being. The profuse perspiration produced by active physical exercise is somewhat different from that produced under states of mental excitement, the former arising in hyperæmic conditions of the skin, and the latter, it may be, in anæmic conditions of that texture; the opposite conditions of active physical exertion, and extreme physical collapse, being thus characterised by profuse action of the sudoriferous apparatus.

Sweat is, therefore, a product of nervine, or hæmal,

excretory activity, or both, and is, alike at all times, the result of circulatory agency. Moreover, sweat represents one of the *final* results of the manifold changes to which the nutritive materials supplied to the body are subjected,

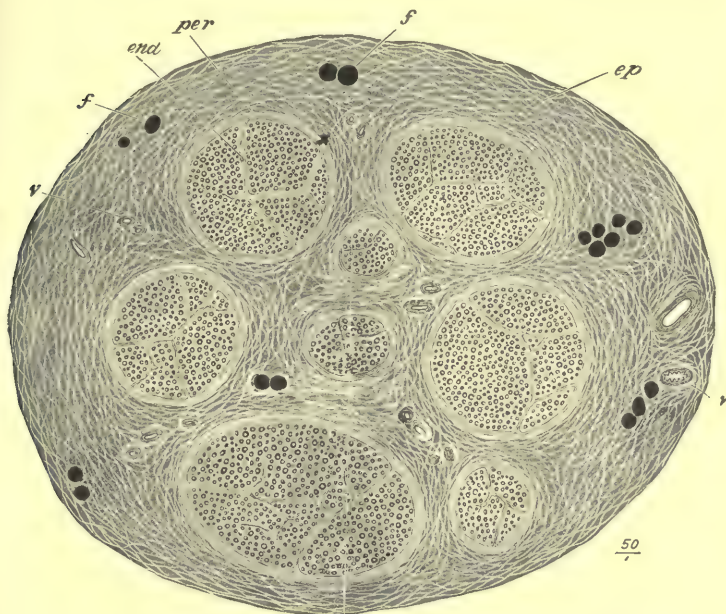


FIG. 65.—SECTION OF THE INTERNAL SAPHENOUS NERVE (HUMAN), MADE AFTER BEING STAINED IN OSMIC ACID AND SUBSEQUENTLY HARDENED IN ALCOHOL. Drawn as seen under a very low magnifying power. (E. A. S.)

Ep, epineurium, or general sheath of the nerve, consisting of connective tissue bundles of variable size separated by cleft-like areolæ, which appear as a network of clear lines, with here and there fat-cells *f f*, and blood-vessels *v*; *per*, funiculus enclosed in its lamellated connective tissue sheath (perineurium); *end*, interior of funiculus, showing the cut ends of the medullated nerve-fibres, which are imbedded in the connective tissue within the funiculus (endoneurium). The fat-cells and the nerve-fibres are darkly stained by the osmic acid, but the connective tissue of the nerve is only slightly stained.

in their passage *from the outer world, to the outer world*, and affords one of the best examples of the adaptability of the principles of *circulation* to the production and elucidation of physiological phenomena, as they are displayed in the life and working of the human body and of all living, or organic, bodies.

EXTRACT XV.

ON THE NUTRITION, AND METABOLISM, OF THE SYSTEMIC NERVOUS SYSTEM, OR SYSTEMIC NER- VINE NUTRITION.

THE theory of nutrition generally, but, more specially, the theory of systemic nerve and muscle nutrition, must, we feel, require revision on our part, in consequence of our entertainment of the foregoing views. We, therefore, are now impelled to attempt the task, and to put on record some of the views on the subject, as related to the process of nutrition that have presented themselves to us, from time to time, as the progress of these studies allowed, or suggested, and as the varied aspects of the particular subject, pursued at the time, have presented themselves, and novel views have consequently been obtained, as we have been "carried along the streams" of exploration, observation, and deduction, while holding aloft the "rush-light" of our already acquired and immediately available knowledge, to enable us to "determine our whereabouts" amid our unfamiliar surroundings.

We have somewhere else expressed, if not fully stated, our belief in the existence of a *secondary digestion*, as representing, constituting, or lying, at the foundation of neuronal nutrition and development, and have stated that the neuroglial matrix of amorphous, and more, or less, developed, substance, deposited amid a feltage of fibrocellular foundation texture (Fig. 66), supplies the pabulum which is, or has been, carried hither by the hæmal circulation, and which is osmotically imbibed and converted, into neural protoplasm by the dendritic rootlet

economy of the neuronal organisms composing the great neuronal commonwealth, or nerve cell union, which goes to make up the systemic nervous system, as displayed in man, and his more highly organised neighbours in "the scale of being."

The pabulum thus supplied to the neuronal dendritic, or secretory, processes, is absorbed and passed into the cell body cavities with which they are related, where it is converted into medullary substance, or enters the nuclear body cavities to form the axis cylinder substance of the various axons, or as a final contribution to the economy of nervine nutrition, it supplies the molecular and

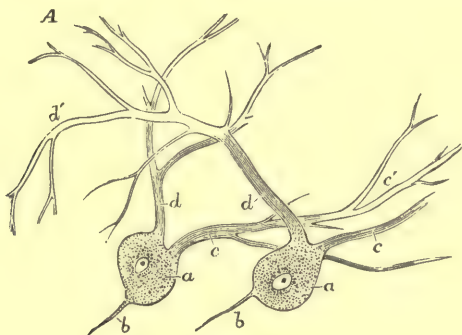


FIG. 66.—TWO NERVE-CELLS FROM THE CORTICAL GREY MATTER OF THE CEREBELLUM. Magnified 260 diameters. (Kölliker.)

atomic wants, of the nucleolar bodies, which latter disposition of the plasma in question, thus constitutes the central and final act of nutritional and formative material organisation, and represents the final, or concluding, material contribution to the evolution of that cryptic union of "mind, and matter," which has hitherto defied "the best laid schemes" of the acutest intellects of biologists, physicists, and metaphysicians, alike, to unravel, or fully appreciate.

The nutritive systemic nervine plasma thus obtained and disposed of is circulated in, or grows along jealously insulated, and continuous, intra-spaces, to the confines of the afferent, and efferent, nervatures, alike, or respectively, where it terminates within, and in continuity with, the structural elements of the skin, and muscles, as a

constituent part of the epidermic and sarcous tissues. Reaching these neuronal limits, the erstwhile proper nerve substance is finally disposed of, by a process of organic shedding, determined by the respective, histoterminal agencies of the voluntary muscular, and cutaneous, textures—the former eventuating, or spending itself, in sarcous disc formation, and the latter in epidermic cell formation, both of which in turn are still further utilised, or disposed of, in a way specifically their own.

Accepting, as we do, *the theory of the neuron*, as being most in accordance with our particular views of the systemic nervous system, we would claim that, each neuron feeds on, or is nourished by, the more or less amorphous, or non-developed, elements of the neuroglial matrix (see Fig. 66), in which it is rooted by its dendritic processes, by a process of osmotic selection, or absorption, that the totality of these neurons is bound up, systematised, organised, and co-ordinated, so as to control the nerve traffic through the afferent and efferent channels, of functional nervine molecular, charge, and discharge, and the passage of nerve energy along the axonal processes within their individual myeline sheaths, and neurilemmar coverings; and that a process of circulation characterises the nutritive economy and nerve force distribution throughout the entire systemic nervous system. Therefore, throughout the whole process of systemic nerve nutrition, circulation is operative, and omnipresent, from its inception in the dendritic absorption of the neuroglial plasma, until that plasma is finally disposed of by the nerve terminals, in skin, and muscle development—the former manner of termination resulting in contributing to the formation of the “outer skeleton,” or skin, the latter, after supplying the fibral formative material wants of muscle, exhausting itself in the production of the synovial fluids, of tendon sheaths, and joint cavities, and contributing to the growth, and maintenance, of the inner, or “true skeleton,” and rendering up its residual material to the bone marrow, and the systemic lymph circulation, for final disposal.

The nutrient course of the systemic nerve plasma, as thus outlined, is a very long and complex one, but yet

no exception to the universal rule that all nutritive phenomena are due to circulation, and, therefore, conducted along definite lines of circulatory spaces, by the operation of definite circulatory forces, for definite nutritive purposes, and definite eliminatory necessities.

In short, nutrition, neuro-sympathetic, and systemic, conjointly constitutes the central, and terminal, or really integrative, act, of the long series of circulatory disposals and preparatory physical changes which characterise the preparation of tissue pabulum for the operation of the metabolic forces which control the chemico-physiological phenomena of the nutritive process, and which has no sooner been accomplished, than the inverse, or disintegrative, circulatory disposal, of that pabulum begins, and pursues its course until its removal from the economy is effected, and room made for fresh material—the round of the changes thus outlined constituting that universal system of organic circulation, of which the “circulation of the blood” constitutes the dynamic centre.

The process of nutrition is, therefore, as continuous and uninterrupted as that of circulation, and consists in the maintaining of the continuity of organic structure, by the substitutive replacement of the displaced particles, in perpetual and unbroken succession, by, or in obedience to the operation of the metabolic laws of change, and exchange and the physical laws of organic circulation.

As thus effected, the onward movement of the circulated organic pabulum is uninterrupted by regurgitation, or the possible admixture of the pure and impure or the nutrient and effete elements, and hence, so long as the physiological balance is maintained, a condition of perfect, or physiologically-sound, health, must obtain, but so soon as it ceases to be so maintained a pathological state of health becomes the result.

EXTRACT XVI.

ON CIRCULATION, AND NUTRITION, OF, AND BY, THE SYMPATHETIC NERVOUS SYSTEM.

TOWARDS obtaining a wider and clearer view, of the applicability of the principle of circulation to the explanation of vital phenomena, as they are to be observed throughout the whole extent of the animal and vegetable world, we would formulate the comprehensive generalisation, that all *life, living action, or vital activity*, including *nutrition*, consists of the movements, or circulation, of vitalised matter, along definite lines determined by, and due to, the definite movement, or circulation, of tissue protoplasm and vital energy. Thus, from the gross movements and circulation of the raw alimentary material, to its final atomic incorporative disposal in the process of tissue nutrition, a continuous chain of circulatory acts obtains which is not even broken when the last vital atomic integrative act continues into, and terminates as, the first atomic act of devitalisation and disintegration except that the circulation of vital energy ceases to be able, or becomes insufficient to maintain, living atomic cohesion, and so allows to begin the disintegrative circulation, and resolution of the devitalised matter into its elementary constituents. Circulation, therefore, according to this view, in its first half, or its nutritive course, in the higher animal world, and, for that part of it, in the vegetable world also, is carried out under the active integrative, and "uphill," influence of vital energy, while in the second half of its course, or after the organic "watershed" of vital eminence has been passed, so to speak, and the play

of vital integrative and cohesive force, has been exhausted, in its long struggle against the powers of inorganic activities, and the natural analytic disposition inherent in metamorphic matter, it is conducted, certainly along paths still actively alive, but in accordance with the disintegrative, "downhill," or adynamic, condition, of *dying, or dead, matter*, and shed through the external surface exits of the organism in question, into the outer world, in quantity *exactly according* with that of the original raw material ingested.

This general process of nutritive circulation requires, for the accomplishment of its purpose, the provision of a "system" of circulatory facilities, or passages, amid the, for the time being, existing matrix elements of the various structures undergoing nutrition, along which the nutritive pabulum can be conveyed, and from which it can be selected, by anabolic attraction for incorporation with, and integration by, the worn, and exhausted, tissues ; and we claim that such a system is afforded by the endothelial lining cells, with their connecting and continuing, fibrous processes—of the capillary network of the blood-vessels, from which the materials for nutrition are extravasated, and from which they circulate into the remotest interstitial spaces of the tissue matrix, and proper structural elements, throughout the organism.

The process of extravasation, or exudation, or extraction, here referred to, may be said to resemble what takes place through the intestinal mucosa, and its overspreading, or lining villi, the latter performing, in the process of alimentary absorption, the same function as do the endothelial cells lining the capillary blood vasculature, which pass their absorbed plasma on to their *process related cells*, for metabolic, or nutritive, use, much in the same way as the villi of the intestinal wall pass on their absorbed chyle, to the lacteals, and related mesenteric glands. Moreover, both these examples of distributive circulation illustrate the adaptation, of the same principles of circulation, to meet very different organic ends, and to accomplish very different physiological purposes, in the economy of *sympathetically controlled nutrition*.

This view of the subject has already been referred to

when discussing the subject of systemic nervine nutrition, but it seems still necessary further to elucidate it, in reference to the nutrition of the so-called non-nervous, or sympathetically innervated textures generally. In studying the economy of general, or sympathetic nervine nutrition, as distinguished from particular, or systemic nervine nutrition, we are impressed with the conviction that the pure, or incoming nutritive material, must be circulated, or conveyed, to the textures to be nourished, along routes, or by vessels, or inter-spaces separate and distinct from those conveying away, or removing, the disintegrated, and effete, or waste, products, of tissue tear and wear. Our conviction, of the consistency and necessity, of such provision, is based, mainly, on the non-existence, in the physiologically healthy condition, of a state of toxicity throughout the whole field of nutritive activity, and on the, consequently, necessary patency of a complete system of eliminatory agencies and organisms by which the escape of effete, and toxic, materials, can be effected in one unbroken succession along the lines of least resistance by efferent vasculatures, so to speak ; moreover, it can only be thus, we think, that such a vitally important function, as that of nutrition, is possible, and that pathological conditions must accrue when any departure from it ensues.

The lymph circulation, therefore, may be regarded as a compound circulation, somewhat in the way we regard the circulation of the blood, as being devisable into a systemic and pulmonary circulation, or perhaps, more aptly, as we regard these two circulations as being devisable, respectively, into arterial and venous circulations joined, respectively, by a capillary circulation. The afferent *liquor sanguinis*, or nutritive lymph, circulation, may be compared with the arterial circulation, the efferent, or effete, circulation, with the venous circulation, and the uniting, or integrative, textural circulation, with the uniting, and anastomosing, capillary circulation. Thus, we see, by a continuation of the application of the principle of circulation, along a proper vasculature and system of inter-spaces, the method, and manner, of the complex function of nutrition become clearer, and more definite. Our contention being that the solid structure of the body is made up of two kinds of

cells, according to the manner of innervation of its various textures, called, respectively, neuro-sympathetic, and neuro-systemic, according to which division of the nervous system they belong. We therefore, further, feel warranted in venturing the opinion, that these two systems of innervation being the producers, and circulators, of nerve force, along definite lines, and through definite structural channels, are *likewise* the distributing and circulating media of the tissue protoplasm, or pabulum, along, and through, the same channels, in virtue of their absolutely ubiquitous inter-cellular and intra-cellular distribution, and continuity of lumens, and texture. Thus, we are enabled to perceive that each endothelial cell of the total capillary vasculature becomes a means whereby the nutritive pabulum is removed from the blood circulation and conveyed by its processes of attachment and inter-communication to distant cells, and groups of cells, and fibrous textures, and organs, by direct continuity of histological development, and vital oneness of organic structure, and function. We take it, therefore, that the principle of circulation is still in operation, in effecting the conveyance of the nutritive plasma from the blood, to the tissues, and that we must grant to the cell and fibre elements involved, the possession of miniature capillary channels, and energy, enough, albeit nervine, to effect the required circulatory movements, under the selecting and distributing supervision of the sympathetic nerve economy, until the final act of tissue nutritive assimilation is accomplished, and the integrity of the tissue elements made good—all which is effected, on lines calculated to secure purity of nutritive material, and to obviate effete admixture, or auto-intoxication, in the all-important process of nutrition.

Nutrition having been thus effected by cell, and fibre, selection, circulation, and distribution, and the final metabolic changes in the integrative disposal of the tissue plasma having taken place, we may be prepared to find that the integrated material, after a longer, or shorter, period of textural detention, or, until tear, and wear, have done their work, resumes, or continues, its course of circulatory movement, by being disintegrated, and shed, into the rudimentary "effete lymph" inter-spaces of the

disintegrating tissues, where, uniting with that from kindred, and neighbouring, inter-spaces, it finds its course facilitated by the ultimate provision of a lymphatic vasculature, which ultimately conducts it back to the blood stream to be finally disposed of. Thus regarded, the processes of integration, and disintegration, involved in the great process of nutrition, are accomplished on lines altogether conducive to atoxicity of nutritive material, and to unmixed removal of effete residuum.

Living cell and fibre, or process, thus manipulate, and finally dispose of, the nutritive pabulum, or plasma, while a series of inter-spaces and a developed vasculature suffice for the conveyance of the effete material, resulting from the disintegration of tissue, albeit, this vasculature is also possessed of a series of intercalated glandular organisms whereby its effete contents can be returned into the blood, with their composition so altered that their toxic qualities are no longer dangerous, or at least that they can be tolerated until removed by the provided excretory organs, all which accentuates once more the truth of our thesis: *circulatio circulationum omnia circulatio*.

Nutrition, therefore, thus viewed, becomes a process of chemico-mechanical preparation of alimentary materials, of their circulation, along definite vessels, spaces, and inter-spaces, to the tissues to be nourished, of their incorporation, and assimilation, by these tissues, and of their subsequent disintegration, and removal, through a series of succeeding inter-spaces and spaces, into a specially provided vasculature, for atoxic disposal in the blood circulation, from which they came, or by direct excretion. It thus becomes apparent that nutrition, as well as innervation, within a dually innervated body, must be regarded as a dually performed operation inasmuch as the nutritive plasma is taken up and distributed, by the sympathetic, and systemic, nervous systems, respectively, to their several "spheres of influence," or innervation. It must, therefore, further be recognised that nutrition is effected entirely through the instrumentality of nervine dynamic agency, whether in the sphere of sympathetic, or systemic, nerve influence, and that the nutritive plasma is selected, either by sympathetic, or systemic, nerve cells, located, respectively, in the endo-

thelial linings of the blood vasculature, and sympathetic ganglia, and the nerve cells proper of the systemic nervous system, and conveyed by nutritive circulation, along successive histological processes, or lines, and linked cells, to every texture requiring nutritional supplies. From this it follows, that every cell must belong to one, or other, of the nervous systems, and that, consequently, all nutritive processes are the work of, one, or the other, system, hence nutrition is a dually performed function, according to the dual division of all cells, into, sympathetic, and systemic, respectively. Thus, the sympathetic, nourishes, directly from the blood, every texture of the body, save those dependent on the systemic nervous system, besides laying down in the matrix of the neuroglial substance of the systemic nervous system, the "prepared raw material," or pabulum for the nutrition of that system, while the systemic nervous system nourishes, in like manner, every texture directly continuous with itself, on both its afferent, and efferent aspects.

The process of nutrition being, thus, effected through cell agency, along communicating histological processes, or connective fibres, porous enough to permit of plasmic circulation within them, and surrounded by a, protective, and insulating, fluid, or lymph, containing "normal saline," or its equivalent, in both its sympathetic, and systemic, varieties, a continually forward, and unmixed, distribution, of nutritive material is obtained which obviates the occurrence of regurgitation and consequent autotoxis, and eventuates in the metabolic phenomena constituting the act of nutrition, and including both integration, and disintegration.

The act of nutrition varies in extent, with the needs of the tissue, or unit of texture, undergoing nutrition, and is essentially one of supplying tissue molecular, or atomic, wants, due to impaired material continuity, from the effects of functional, or materio-dynamic, tear and wear, and the natural katabolic denudation ever present in all organised, as well as unorganised, substances.

Nutrition, thus, constitutes the central, and ultimate, vital distribution, and incorporation, of the alimentary materials supplied for the body's upkeep—waste, and

decay, following, and completing, the *cycle of changes* undergone by every particle of those materials, in their passage *from* the inorganic, *to* the inorganic world, through the organic intricacies of that body. All the chemico-physiological processes leading up to, and all the chemico-physiological processes following on, this act, but consist of a material preparation for, and a removal of material results from, the scene of that transcendental metabolic vital chemistry, whose purpose is, the maintenance of life, and health, with all that is included therein ; and comprise, the whole physiological phenomena displayed, in the transit of dietetic articles through the body, their resolution into its organic elements, and their final restitution, as inorganic elements, to mother earth.

The vital chemistry involved in the process of nutrition represents the progress, and culmination, of all the vital preparatory processes, preceding, and constituting it, and the advent and progress of the processes of devitalisation, and decay, succeeding it, during which are displayed, phenomena not less marvellous and wonderful than those involved in the origin of individual life forms, or the working out of *organic perfection*, throughout the universe.

As the “means to the end”—the accomplishment of nutrition—it must not be forgotten that the process is only possible, when a complete means of conveyance, as well as, preparation, of nutritive materials, is provided, by a continuous canalling of the whole organism, or body, in virtue of which, and vital dynamics, a circulation, is maintained, of such a complete character, that a way is found to every atomic vacant space, and a fresh atom supplied, by which the atomic continuity of every texture is sustained, and residual materials moved on. From this it becomes obvious that, any departure from a strictly physiological state, in either material, or working, must be followed inevitably by a pathological result, in proportion to the extent, and continuance, of the pathological factors, the removal of which, when it does occur, must, therefore, be sought at the earliest possible moment, by a scientific appreciation of the conditions involved, and the most immediate use of scientifically indicated means.

In conclusion, nutrition may, strictly speaking, and in a word, be described as, the central circulatory act of disposal, in the cycle of circulatory acts of disposal of the elaborated organic plasma, or protoplasm, in its atomic units, to suit the atomic needs of the tissues, and to maintain their functional powers at a normal level, while, simultaneously, clearing them from the presence of their effete, and hence toxic, residual materials : if therefore, nutrition be properly effected, it must follow, that every other vital process must be performed in accordance with the claims of physiological health.

EXTRACT XVII.

ON THE OCCURRENCE OF *VACUA* IN THE ORGANIC, OR METABOLIC, WORK OF THE HUMAN BODY, AND ON "SUCTION" EVACUATION, AND GRAVITATION, IN RELATION THERETO, OR THE DYNAMICS OF CIRCULATION.

THE existence of an absolute *vacuum* is an impossibility, in the everyday working of the human, and every other organic, body, and is only thinkable as a scientific curiosity, the existence, however, of *comparative vacua* throughout nature, is not only thinkable, but constantly observable in that portion of it within our reach.

Thus, the earliest indications in the human infant of its power of self-existence are the creation, by reflex neuromuscular effort, of an uncountable multitude of *vacua*, in its hitherto unopened, or pseudo-impervious, pulmonary parenchyma, in virtue of which an inrush of atmospheric air commences the life-long process of breathing, with all that is dependent thereon of functional and material change and organic work—next to death, this is one of the most marvellous, and important, changes, effected in the history of fœto-infantile evolution, marking, as it does, the beginning of separate and independent existence, the commencement of individual life, and the perpetuation of the species.

The *vacua* created here, in embryonically prepared structures, are effective, till the termination of the individual existence, and by rhythmic repetitions of the original respiratory movement, in maintaining the union between the body, and what constitutes the hitherto inexplicable

entity called the individual life, or the vital principle, the coming and going of which are so absolutely, and visibly, real, but at the same time intangible, and impressing the human intellect with a faith in the existence of a necessary, though hidden, communion, and continuity, between the seen and tangible and the unseen and intangible; and begetting a belief in the reality of the existence of "things not seen." Another *vacuum* formed by the uneducated and but instinctively informed infant consists in the shaping of its oral organs into the form of a "sucker," the working of whose *vacual principle* is so perfect as to secure the means of its material sustenance and growth and the maintenance of that community of existence and feeling between it and the maternal organism so essential in its then helpless manner of life. Who is there, it may here be asked, who cannot see in this co-existence and interdependence, the greatest factor, not only in securing a proper receptacle for the indwelling of the vital principle, but the greatest educative power and so-called hereditary influence which can be brought to bear in the formation of future character, and the shaping of destiny, in the generations which have lived, and those which are to live?

The oral *vacuum* with which independent existence begins, continues to be formed, in obedience to the law of organic demand, dictated by sensations of hunger and thirst, and has to be occupied, or filled, as long as life continues by its proclaiming the material needs of the body, and doing its best to satisfy them so long, as these are supplied by the outer world in quantity and of quality, suitable for its purpose. *Suction* literal, or modified is the prime moving factor in all such processes of vacuum formation, and is accomplished by appropriate structural disposition of nerves, muscles, and subsidiary tissue elements. Thus, the infantile oral *vacuum* into which the maternal mammary apex is inserted secures by suction, or the creation of repeated *vacua*, the passage of the mammary fluid into the mouth, and alimentary canal, and the nutritive economy of the infantile organism—a process which, of course, necessitates the existence of a previously prepared series of open spaces, or a vasculature, affording the required *vacual* facilities.

A pre-natal histological arrangement of the embryonic, and foetal, structures, has been effected which only requires the advent of independent existence to be turned to account to secure the subsequent continuance of life, on the altered post-natal plan, and this consists—like the launching of a ship into its future watery element—of the opening of hitherto closed sluices and the letting in of the gases, fluids, and solids, of self-sustainment.

After this process of sluice opening and the inauguration of independent existence, a connected, and continual, series of circulations is evolved, or established and perpetuated which disposes of the alimentary materials, on the principle of continuous evacuation and renewal, or replacement, by the formation of *vacua*, and vacuoles, and the refilment of them by fresh materials—these *vacua*, and vacuoles, acting as so many suckers, in the economy of the nutritional disposal of tissue pabulum, on the oft-quoted, and conveniently available, principle, that “nature abhors a *vacuum*.”

The modes of force in use in the accomplishment of these circulatory phenomena are neuro-muscular, or dynamic, action, capillary attraction, and chemical affinity, initiated, and sustained, by vitality, or life; the circulatory ways, or textural inter-spaces along which the fresh organic plasma, and the effete, or waste tissue products, are conveyed, being organised vessels, tissue porosities and molecular vacuoles, or atomic voids. Activity of the organism and the exercise of the nutritional machinery, cause molecular displacement, or waste of organised texture, or evacuation of the molecular spaces of these, with the consequent creation of molecular vacuoles which, thereafter, “cry out for,” and attract, or “suck in,” the required molecules of fresh plasma—which process keeps repeating itself, as long as the conditions of life are effectively sustained.

From these statements we are warranted in concluding that all vital processes consist of an unbroken graduated series of circulatory movements along definite organic channels varying in available circulatory capacity from the primary alimentary canal, to the ultimate atomic, or molecular, vacuole, and from the ultimate atomic, or molecular,

vacuole, to the primary alimentary canal and the various other excretory orifices of the body generally.

All these vital circulatory phenomena are thus, to a great extent, antagonistic to the great law of gravitation, and it is only when pathological conditions are evolved, that that law is able to reassert, or manifest, its powers, in opposition to those of vitality, and health ; therefore it is only on the complete arrest of vitality, or at death, that that law resumes a complete sway over organised matter.

In this connection, however, it may be pointed out, as an indispensable condition of life and health, that the complete and effective removal of effete, or worn-out, organic material, is absolutely essential, and that that condition is provided by the law of gravitation, in that it immediately removes organic debris as it is detached from, or ejected by, the evacuant machinery of the body. Moreover, we are further warranted in concluding that thus, the law of gravitation is providing a *vis a fronte*, which is effective in securing the necessary external void, or voids, for persistent forward suction and evacuation and the maintenance of a continuous intra-corporeal circulation, masticatory, digestive, sanguineous, nutritive, and excretional, with the many connecting and subsidiary circulations, making up the great organic circulatory whole. Organic opposition and antagonism to the law of gravitation ultimately end, in entire inorganic acquiescence in the inexorable requirements of that law, and what has, for a shorter, or longer, period, been in active organisation and functional use becomes reduced to its original inorganic elements, in which it may again assume, under the influence of other organic forces, another term of organic existence ; and so the great problems of life and death are continually being solved in the experiences of, at any rate, the surface layers of the earth's crust—a conclusion which witnesses once more to the truth of our expression and contention: *circulatio circulationum omnia circulatio*, and that the whole universe is in a state of flux, and that nothing is *at rest, really*, whatever it may be, *relatively*.

Making a somewhat larger generalisation, on these lines, we feel, in conclusion, warranted in stating, that life

consists in the *temporary arrest* of the *complete reign of gravitation and inorganic laws* by the *whilom erection of an organic barrier*, by, or in, virtue of vital energy, operating through formative impulse, along definite lines of organic accretion, to living organisms—such living organisms being ultimately overtaken and subdued by the “*all-prevailing*” *inorganic laws*, but not, as a rule, before they have secured their survival, and the perpetuation of life, by transferring that life, in sufficient proportion, to maintain an effective resistance, in the perpetual strife of organic, and inorganic forces, and to secure the *continuous existence* of life, active intelligence, moral energy and purpose, and future destiny.

The principle of the accelerative influence of the *vacuum*, and vacuole, in the economy of circulation throughout the body, seems to us to find employment in the phenomena of muscular action. Thus, muscular contraction, as displayed by individual muscle fibres, is rhythmic, *i.e.* rest, and contraction, alternate with each other, the rest allowing the muscle fibre to recover itself, both as regards substance and energy, and the contraction displacing both substance and energy along the lines of least resistance, each contraction, and period of rest, constituting the two halves of a whole operation, which, repeated, and repeated, make up the life experience of every muscle fibre, striped, and unstriped. To use a familiar simile, we might compare the contraction of a striped muscle fibre to the reduction of a fully extended accordion, or concertina, to its ordinary proportions, or what it is in a state of rest, by the withdrawal of impediments to its resumption of that position, or by the application, it may be, of a compressing force. During this change the interior of the instrument is emptied of contained air, and collapse of it is the consequence. In the case of contraction of a muscle fibre due to the effect of nerve energy on the contractile substance of the fibre, the intra-fibril contents are, or must be, more or less, displaced, according to the intensity of the determining influence, with the result, that the fibre, on the re-attainment of its normal proportions, must give rise within itself to the formation of a series of discal vacuoles

proportioned to the extent of the contraction. What then must occur to rectify the disturbed balance of fibril material occupancy which must here be regarded as a nutritive requirement, and the satisfaction of which is essential, if the phenomenon of contraction, or muscle work, is to continue? Clearly the filling of the discal vacuoles by *suitable* material for the influence of nerve energy to be felt, and the phenomena of muscular contraction to be renewed. Where then can that suitable material be derived from? In our opinion it is derived from the nerve terminal plates, or fibrils, which are communicated to every sarco-s disc, and through which are conveyed from the central nervous system, the material necessary for muscle nutrition and regeneration. Thus, the neuro-musculature is, one, and indivisible, self-supporting, and only inter-penetrated, and held in proper histological position, by the sympathetically innervated interstitial elements. No doubt it is impossible to eliminate the many important inter-dependencies, material, and functional, of the two nervous systems, in their great conjoint work, of running the organic machinery of the body, but it is obvious, that while there is reciprocity in every possible manner, there is a *distinct*, as distinguished from a *conjoint*, *adaptation*, to perform certain specific work, organic, and functional; the recognition of which is absolutely necessary, if we are to be possessed of what is entitled to the name "a scientific knowledge of the subject"—muscle disc plasma is thus derived from nerve plasma which, in turn, is derived from nerve cell selection from the matrix of the neuroglia which, in turn, is derived from the blood plasma, the product of the primary alimentary materials, the *ingestion* of which constitutes the great necessity of life.

Belief in these statements, entails belief in the existence of powers of circulation, by structures which have hitherto been tacitly regarded as solid, or homogeneous, and incapable of allowing the passage of material along their constituent fibril elements. Circulation of material and energy alike, as we have elsewhere endeavoured to prove, is a *root property*, or *foundation*, *condition*, of all matter, whether inorganic, or organic, and must be accepted as

axiomatic. It, therefore, follows, that the phenomena here referred to are no exception to the rule, and that circulation takes place, along the lines of least resistance, which, here, are clearly what we have imperfectly stated.

Circulation of matter, in its organised form, we, therefore, regard as the result, primarily, of gravitation, inasmuch as the first void space, or vacuole, is created by the exit, or detachment, from the substance, or texture, in which circulation becomes established, by the attractive influence of gravitation after which the void, or vacuole, becomes re-occupied, in virtue of the operation of this *vis a fronte*, as well as, by the help of whatever *vis a tergo* may be available, or inherent, in the particular structural circumstances. Gravitation plus the operation of vital energy, which we claim to be equal to nerve, allied with physical, chemical, energy, or life, and other modes of physiological force, or attraction, constitute the causes of circulation in a living organism ; this circulation being effected along the lines of least resistance within that organism, it follows that the life of that organism will be maintained, as long as these forces are capable of propelling the required organic pabulum along these lines. From this likewise follows that the great desiderata, scientific, and practical, are the securing of the effective operation of these forces, and the maintaining of a free passage along these lines, for the distribution of nutritive pabulum, and the elimination of effete matter.

Nutrition, as considered in the light of these views, becomes the central act of the circulatory work of the organic body, or the central link of the great chain of vital intra-organic distribution and structural integration of tissue plasma on the one hand, and the disintegration and re-collection of the effete tissue material, or waste, on the other. It must, therefore, be effected where the tissue plasma has reached the atomic, or molecular, stage, of distributive division, where the final units of that plasma fit into the atomic voids, or vacuoles, of the tissue fabric, and when, if there is any rest for the circulating material, it might be conceived that it is here attained. This conception, however, would be found to be a misconception, inasmuch, as this is, *only*, the *longest*, or the *shortest*,

day in the organic time cycle, and must, therefore, be reckoned, as of the same duration, as those immediately before, and after. The rate of the circulation of the structural elements, for the time being, therefore, of any living structure, at any instant of time, must be determined by the rate of circulation of the atoms, or molecules, composing them, and, consequently, by the consistence and relative mobility of these, for the time being.

Nutrition, being the central disposition of the tissue plasma within the structural elements of the organism, is effected by the resident organic forces operating under physiological impulse, resident in, or emanating from, the living tissues, and supplied from resident nervine sources, and is, thus, a thing, not primarily effected by central or systemic nervine influence, but by the sympathetic nervature, it may be, of course, after drawing on the resources of the central nervous system—nutrition is, therefore, an entirely sympathetic nerve operation, so far as administration, so to speak, is concerned, and hence, so far as we can see, it is not due to the existence of any particular central systemic nerve mechanism, or trophic nervature, or centre.

The foregoing applies to the textures and viscera innervated by the sympathetic nervous system, and, more or less, to those dependent for innervation on a combination of the two nervatures; while the nutrition of striped muscle, wherever situated, must be regarded as entirely effected by systemic nervine agency, through neuronal, absorption, conversion, and utilisation, of neuroglial plasma, or material, and axonal conveyance of it to the muscle “end plates,” and its final fibril distribution to the sarcous, or muscle discs. The nutrition of the interstitial muscle substance, being derived from, or effected by, the blood (Fig. 67), under sympathetic nervine influence, is not affected, except indirectly, by systemic nervine conditions, hence the occurrence of such affections, as pseudo-hypertrophic paralysis in which the one element of muscle disappears, while the other remains, at least, for a time—the systemically innervated and nourished representing the former, the sympathetically innervated, the latter.

Functional activity of the muscular tissues is always necessary to maintain their nutrition, while disuse entails atrophy of their sarcous element, and finally of their interstitial element also, the lapsed *raison d'être* of the existence of the proper muscular elements ultimately leading to their entire disappearance—which state is

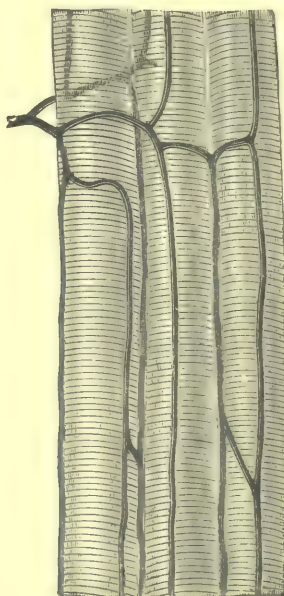


FIG. 67.—CAPILLARY VESSELS OF MUSCLE. Moderately magnified. (E. A. S.)

represented by that singularly impressive disease known as myopathy—the subject of which ultimately becomes literally “a living skeleton,” bereft of every texture dependent on systemic innervation and nutrition, and a monument of sympathetically innervated and supported organisation, in which, the once presiding psychic energy is pent up in helpless solitude and isolation, amid the decaying, and ultimately ruinous, neuronal remains, of the cerebral and higher systemic centres.

EXTRACT XVIII. A.

ON SECRETION, AND EXCRETION—SO CALLED SECRETION.

SECRETION, as a word, or scientific term, signifies a separation from the blood of a fluid, meant for a physiological use, or for excretion, as effete, or noxious, and hence is applied to the functional work of a series of anatomical structures called glands—ducted, and unducted, or ductless.

The view has hitherto been prevalently held, that the material constituting the secretion was derived from the blood directly, through the instrumentality of certain secretory cells possessed by these glands, and this view we are not about to dispute, further than that it should be amplified, and should be made to include another source of supply, viz. the nervine. Our reason, for advancing this heterodox opinion is derived from a survey of the circulatory and structural elements entering into the histological composition of every gland, whose circulatory contents are necessarily physiologically affected by the specific secretory mechanism of those glands, from their entry into, till their exit from, them. Circulation within a gland, according to the results of our investigation of the subject, is three-fold, in accordance with the number of vasculatures histologically observable therein, *i.e.* it consists of a blood circulation, a lymphatic circulation, and a nervine circulation, the half of the first, and the last, of these, being afferent, and the remaining half of the first, and the second, efferent.

From this, we may conclude that the blood, and the nervine circulations, are alone engaged in contributing

the elements of which the secreted fluid is composed, and that the lymphatic circulation is concerned merely in conveying, or removing, the results of the gland tissue waste, proceeding from the functional activity of the gland structure proper. If this be so, and we are unable to conclude otherwise, we see, in every secretion, the results both of blood and neural fluid disposal, some of which must be regarded, as supplying materials for further functional purposes in the economy, and some, as removing from these circulations, for hygienic reasons, materials whose continued presence there has become a menace to health, and whose removal has been thereby a physiological necessity.

Secretions of both descriptions may be cited, in order to illustrate the truth of these remarks—thus, as types of secretions whose value consists in aiding the vital working of the body, we select first the ductless glands, which secrete materials destined to continue in, and to affect the physiological working of the blood, and second the kidneys and sweat glands whose office it is to separate, and to eliminate, materials altogether effete, and exhausted of further functional usefulness. Of the mixed class of secretions, we would cite third those formed along, and connected with, the lumen of the alimentary canal, whose chemico-physical powers, as digestive agents, are still utilised for great physiological purposes, and whose re-absorption in, and amongst, the digested pabulum, in a consequently modified form, is again effected.

In regarding the ductless glands as great agents in the elaboration and vivifying of the blood plasma proper, we think we perceive a *great meaning* in the expression, and realise that a ductless state of those glands is not only consistent with, but a necessary structural condition for, enabling them to retain, and pass on, in the blood circulation proper, the entire results of their functional activity unaffected by admixture with adynamic, or noxious, substances, and physiologically capable of meeting the material and dynamic necessities of nutrition, throughout the organism.

Secretion, therefore, becomes a function of a most

varied character, in the economy of vital integration and disintegration, and employs an array of organic structures, and devices, of the most elaborate, and cunning design, whose influence in securing the health, and physiological working, of the whole organism, it is impossible to overestimate. It is concerned in, and at, every stage of alimentation, nutrition and excretion, assisting in the performance of every physiological stage of the materio-vital work of the economy, selecting, and passing on, the elements of nutrition and separating and eliminating the elements of decay, thus maintaining the balance in equal poise of tissue integration and disintegration.

Every cell wall and nuclear sac thus becomes, to all intents and purposes, a gland, whose function it is, by osmosis, to convey, or pass through it, the currency of nutritive plasma and the used up elements of its contained structures. On the balance, therefore, of their individual and communal functional performances, depends the condition of the body, as to the incidence of health, and disease, and the amount both of physical, and mental comfort and happiness enjoyed by the individual being.

Secretion, as a physiological function, must, therefore, be followed by circulatory disposal and utilisation and by structural integration of the secreted fluid, or its excretion, and it must be continually borne in mind that rectification of this régime, when faulty, becomes the first duty of the members of the healing art; its close study and appreciation must, consequently, be regarded as one of the foundation qualifying duties of each and all of them—if they are scientifically to apply the principles of therapeutics, and surgery.

Excretion, as a physiological term and process, has a much more restricted meaning than secretion, being applicable only to the final acts of material circulatory disposal, in the economy of nutrition, and embraces the eliminatory functional acts of the bowel, kidneys, skin and lungs.

Excretion is concerned entirely with the disposal of the egesta, and its scope, when healthy, entirely accords

with the quantity of materials ingested, the egesta and ingesta, necessarily balancing each other in gross quantity, although varying in state of chemical and physical combination, the difference between them, in composition, and dynamic qualities, being represented in terms of the production and expenditure of vital energy and the maintenance of life.

As physiological terms, secretion and excretion apply, in great measure, to the initial and terminal extremities of the process of nutrition, and are due to, or consist of, osmosis through gland, and every other form of cell wall, of the nutritive plasma, on the one hand, and of effete structural substance, on the other, hence the necessity why they should exactly balance each other, in order that the material *status quo* and the dynamic equipoise should be maintained in undisturbed, and finely adjusted proportions.

It becomes evident from this that the initial departure from health dates, or may date, back to the first indication of disturbance in the process of nutrition, or in the phenomena of integration and disintegration, locally, or generally ; or, in short, to derangement of metabolism in its most intimate nature, as lying at the foundation of all life, or vitality.

Secretion and excretion, as physiological terms, applicable in a description of the metabolic phenomena of living structure, seem to us to require modification, resetting, or substitution—thus, the final act, or phenomenon of nutrition, consists in, or of, the secretion of plasma, by, or rather, the secreting, or “hiding” of plasma in the molecular interstices of the histological elements known as the tissues. Living structure, we would, therefore, regard as the culminating, or final, result of vital construction, preceded by preparatory physical change, and followed by destructive re-arrangement, or katabolism, of its elements, in rhythmic order, and sequence—its actual component parts, for the time being, consisting of its own proper, or intrinsic, chemico-physiological constituents, or elements, in a state of stable, or loose, arrangement, and cohesion, thus exemplifying in every degree, the rate and manner of the vital physico-chemical circulation and

living textural endurance, skeletal resistance and tissue disintegration.

Secretion consists, essentially, of the endosmotic disposal of certain elements of hæmal and neural lymph, or plasma, while, in like manner, excretion consists in the exosmotic disposal of these elements, constituting the living tissues of the body, the combined operations being effected by one continuous process of osmosis, through the cells and cell processes, or fibres—each fibre being, therefore, a nutritive plasma vessel and nutritive material distributor.

A full understanding of these phenomena, thus, involves a complete appreciation of the whole process of nutrition, or metabolism, in all its phases, material and dynamic, integrative and disintegrative, synthetic and analytic. Occurring simultaneously with the phenomena of metabolic conveyance and disposal are the phenomena of chemico-physiological arrangement of the atomic elements of the tissue plasma, in accordance with the molecular affinities, constitution and necessities of the various tissues, or structural developments, of the body, and, therefore, the rounding off and the inclusion of the complete processes of nutrition and the chemico-physics of life.

The terms constituting the terminology and phraseology of metabolism, introduced as its manner of working has become understood, as the literature of the subject has evolved itself, and its essence has become scientifically embraced in the sum of knowledge, seem to us now to offer the desired opportunity for re-moulding, in accordance with the requirements of modern scientific progress, a physiological terminology, which is in danger of becoming obsolete, and no longer capable of exact disposal in the structure of the language of research and accepted truth. While we thus call attention to the growing want of a scientific terminology, in proportion to, and in keeping with, the advance made by truth, we would, at the same time, sound a note of warning, that the old terms must not be parted with, without the general assent of all those engaged in the work of teaching the accepted truth, lest the danger of losing a complete command of the old,

before a proper understanding of the power and manner of employment of the new has to be met. The historical evolution of the groundwork of science generally, as well as of physiology in particular, has been slow and, to some extent, fitful and halting, but it has been wonderfully consistent and conservative, so that we may believe that any studied effort to amend and expedite progress here will be followed by the supply of a "felt want" and that it will maintain the continuity of the evolution of the terminology, and phraseology of a subject which lies at the very foundation of a department of physiological knowledge, which, itself, is now so extensive as to underlie much of the adjoining special sciences of anatomy and pathology, and to pervade the texture of the general subject of biology, which may be said to include the whole of animated nature.

While thus calling attention to the necessity of amending the manner of use of the terms secretion and excretion, we forbear offering, in the meantime, any suggestion as to their modification, substitution, or abrogation, having personally a great veneration for them, begotten of the great services they have fulfilled in our everyday life and work, and our appreciation of the difficulties involved in "changing the fashion," and clothing anew "subjects of thought" which have passed current during the great advances characterising the recent progress of physiological, pathological, and chemical knowledge, and experience.

Bound up with the terms secretion and excretion is a clue to the origin and derivation of the earliest periods of their growth and evolution leading back to a period when the vernacular tongue was more in use, in the expression of scientific facts, and the application of a knowledge of those facts to the everyday requirements of mankind. From which we feel warranted in concluding that that clue is made up of a compound thread emanating from both sacred and secular sources, the skeins of which have been gradually lost, as the divorce between religion and science took place, and the thread, at last, "made up" of the solitary fibre of science. In this divorce, the "secret," of the rapid

advance of science and the comparative non-progression of religion is to be found, and the reasons for much of their mutual distrust and antagonism, discovered; as well as the necessity for their again uniting their efforts in applying the practical advantages, to be obtained from their combined use, in the constantly recurring vicissitudes marking the life and experience of man. *Secrets* are no longer necessary to the progress of science; indeed they constitute the problems in the elucidation of which its best efforts are spent, and, the wider, and fuller they become known to humanity, the quicker will be the progress of civilisation, and the amelioration of the lot, of man. *Secretion*, therefore, appears somewhat of an anachronism in this period of the world's history, and might be amended, on the lines hinted at above, with advantage to the interests of scientific progress and the advance of exact knowledge—if, however, it be found possible, or best, to retain it without detriment to progress, scientific, and literary, we shall be prepared to cherish it, as its importance demands and deserves.

EXTRACT XVIII. B.

EXCRETION.

It may be said, in its widest sense, that excretion represents the return, into the "outer world," of the residual products of the raw materials of the food and drink taken into the body, of the unutilised type—solid and liquid, of the solid, and liquid results of waste and disintegration, and of the gaseous elements, or results, of chemical interchange, which have not entered into, or which have been released from, solid and liquid, combination, or association. Typically its forms consist of the alvine, the renal, the cutaneous and the pulmonary, and they may be grouped around two great nerve areas and two great lymph systems, viz. the sympathetic, and the systemic nervous systems, and the hæmal, and neural lymph systems, respectively. The kidneys may be said to excrete, mainly, from the sympathetic nervous system, or area, the residual hæmal lymph; the skin, in like manner, the peripheral systemic, and the sympathetic, neural lymph—that of the systemic motor area finding its way into the hæmal excepted—and the bowel, an admixture of both systems; while the lungs give off, the great proportion of the effete gaseous material, the skin and bowel, also contributing. It will be seen, from this division of excretory labour, that the hypo- and mesodermal areas, with a division of the ectodermal, are dealt with by the kidneys and bowel, while that of the systemic sensory area, together with part of the outer hæmal, is accomplished by the sweat agencies of the skin, the

work of gaseous excretion being achieved conjointly, by the lungs aided by cutaneous and intestinal transpiration; it, therefore, follows, that we must look, in a great proportion of the diseases of these areas, for the clue to their etiology and relief, or removal, in the condition, as to closure, or patency, of the excretory canals, and emunctories.

Therapeutic, and other, agencies of the medical man, must, to a great extent, be classified in accordance with these physiologico-pathological conditions, and indications for their use be found, according to the excretory area and agency involved in the individual case; accordingly what are known as diuretic, purgative, diaphoretic, and depletive remedies, are likely to be mostly indicated, while, in a lesser number of cases, remedies having an opposite effect, viz. astringent, etc., may, in like manner, have to be used, as when excretion is exaggerated. Of course, when advanced pathological states of excretion have been attained, when chemical, bacterial, or other morbid changes have ensued in the excretory structures and the matters excreted, then, a wider range of choice of remedies will have to be sought, to meet the super-added pathogenic states and influences.

Akin to excretion is "casting off," or exuviation, of the skin and its appendages, and denudation of the free surfaces of the body,—wherever situated, this process continually proceeding, and requiring for its maintenance due attention to its details, as the condition of perfect health is impossible without it; moreover, certain morbid states owe their origin and continuance to the neglect of nature's requirements in this matter, and propagate themselves on, or in, the unremoved "cast off" textures of the body.

It follows, from the above, that constant removal of the effete materials, thus continually being freed from all parts of the body, represents a *sine qua non* of health, and it behoves every person, therefore, to see to it, as a matter of everyday personal routine, as an incentive to which, it may be well to recapitulate that the necessity for it depends on the existence of a physiological law, which is always operative, viz. that *the body*

gives out an amount of material, equal to what it takes in, and, therefore, if any departure from its excretory requirements be permitted to take place, a disturbance of health in proportion thereto must, sooner, or later, ensue.

EXTRACT XIX.

ON GLANDULAR STRUCTURES, OR ADENOGRAPHY GENERALLY.

THE structural and functional generalisations of the older schools of anatomy are characterised by a firm and wide grasp, of principles, an accurate appreciation of structural detail, and knowledge of functional rôle, not by any means second to that displayed by the new, and more fully equipped, modern schools, and in no department of structural anatomy is this more apparent than in that of the glandular.

The structures grouped as glands represent a large and most important order of organs, the functional rôle of which is of the most vital character, in the operations of organic life, as well in the preparation of pabulum for integration purposes, as in the rearrangement of disintegrated material and effete products, for final excretory disposal; they have been, by common assent, divided into two classes, viz. glands which empty their contents by a duct or ducts, and glands which are said to be ductless (Figs. 68, 69); this division, or classification, is convenient, but, as to whether it is anatomically true, we have our misgivings, because the nature and function of the gland, must determine whether its secretion is to become immediately an excretion, or whether it is formed for further use in the economy. Looked at from this point of view, the ductless glands may be regarded as entirely belonging to the latter class, or those whose secretion is for further use in the economy, while a large proportion of the ducted glands also discharge through their ducts

materials, which are utilised for further purposes, before their final excretion, only a comparatively limited number of these glands primarily discharging their contents, as no longer necessary and altogether effete.

Adenography is a subject of such large proportions, that nothing less than a treatise would suffice to embrace it. We shall, therefore, content ourselves with a very restricted

FIG. 68.



FIG. 69.

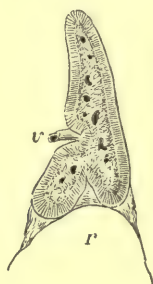


FIG. 68.—FRONT VIEW OF THE RIGHT KIDNEY AND SUPRARENAL BODY OF A FULL-GROWN FÆTUS. (Allen Thomson.)

This figure shows the lobulated form of the fetal kidney, *r*; *v*, the renal vein and artery; *u*, the ureter; *s*, the suprarenal capsule, the letter *r* is placed near the sulcus in which the large veins (*v*) are seen emerging from the interior of the organ.

FIG. 69.—SECTION OF THE SUPRARENAL BODY. (Allen Thomson.)

A vertical section of the suprarenal body of a fetus, twice the natural size, showing the lower notch by which it rests on the summit of the kidney, and the anterior notch by which the veins issue, together with the distinction between the medullary and cortical substance.

and general, survey of the subject, so as to afford an outlet for the expression of certain views regarding it, that have presented themselves to us, as we have been studying subjects in some way related to it. The principle, or function, of secretion, is entirely monopolised by gland structures, although kindred operations are performed by every cell body, the quasi-homogeneous wall of which is capable of passing through it the material necessary for its growth and maintenance, besides, in the *non-processed cell*, the kindred and related function of excretion, the only exception to which is said to be the nerve cell, which is

said not to excrete, but which, we have already contended, is no exception to the rule.

Arranging gland structures around the principle, or function, of secretion, and on parallel lines with that of circulation, regardless of their anatomical structural arrangements, as to ducts, or no ducts, we shall begin and continue their survey and classification along the lines by which the elements of food are taken into the system, utilised and finally disposed of, as excretory matter. Accordingly we would recognise the alimentary canal, or tube, as the great and primary secretory organ, or gland, whose office it is to secrete, or select, from the materials passed through it, the raw materials, or elements, out of which the secretory organs beyond can expiscate and select the various nutritive, or plasmic, materials required by the various structures and organs of the body: this great primary secretory process being effected by the mucosa lining it, assisted by the countless glandular agencies and effluents with which it is surrounded and inter-penetrated, assisted by its own vermicular manipulative action and mechanical trituration. Next, and originating in the wall of the intestinal canal, the vascular textures of the blood circulation and lacteals take up and continue the process of secretion, and dispose of their products of the blood directly, and to the mesenteric, or chyliferous, vasculature, with its peculiar and vivifying, glandulature and long ducts, ending in the blood vasculature, which blood vasculature conveys it to every texture, after leaving the left side of the heart, for a renewed process of secretion, and selection, by the lining membrane of its ultimate, capillary distribution, and endothelial cell osmosis. This process of secretion, may be called the process of nutritive secretion, and assimilation, or nutrition proper, and the last stage in the integrative disposal of the nutritive plasma, in its course of metabolic, or rather anabolic, change. Secretion is a process, therefore, in which a great variety and number of tissues, besides the proper gland structures, take part, and may be said to constitute the whole processes of digestion, gastro-intestinal absorption, chyle and blood circulation, and tissue assimilation, or formative disposal, of organic plasma; which organic

plasma may, thus, be said to be nutritively secreted by a prolonged, but consecutive, series of unbroken vital physico-chemical changes and circulatory disposals beginning in the ingestion of the food, and terminating in its assimilation by the tissues. Assisting, and making effective, this nutritive secretion, or assimilation, would seem to be that order of glands called ductless, at least those known as the spleen, thyroid, thymus and supra-renal, which are attached to, or dove-tailed into, the blood circulation; the others, such as the coccygeal and carotid, as well as the glandular structures known as the pituitary, pineal and lachrymal, or ophthalmic and auditory lymph spaces, with their associated nasopharyngeal excretory mucosa, being related to the cerebro-spinal lymph circulation. Besides, another extensive and well-marked series of true gland structures is the lymphatic, which is entirely involved in the involutionary disposal of systemic, or hæmal, lymph, and whatever finds its way into the hæmal lymphatic system of vessels; while still another, and one which is connected with the change of the chyle into blood, or the evolutionary disposal of the raw alimentary material, is the mesenteric system of glands.

As thus outlined, secretion, as applied to nutritive assimilation, is effected by a series of physiological changes, in the nature and character, of the ingested materials, whereby they are elaborated, energised, vitalised and prepared for assimilation by the tissues, in the accomplishment of which, the intestinal mucosa, the blood and chyle vasculatures and the great ductless blood glands take part, each and all, in their own way, contributing their quota to the great work, of nutritive secretion, conveyance and integration.

Secretion, as here described, is one evolutionary process terminating in the metabolism of the entire tissues of the body, and is followed by an involutionary process, or katabolism, by which the secreted and metabolised, materials are finally broken up and restored to the outer world as absolutely effete and devitalised.

EXTRACT XX.

ON THE PHENOMENA OF "SKIN MARKING" AND SKIN EXFOLIATION, EPIDERMIC "SHEDDING," OR SOLID EXCRETION.

IT goes without saying that the manner and sequence of dermal and epidermal change, in regard, both to rate of growth of the skin elements, the length of time characterising the life of these elements, and the tardiness, or rapidity, of their progressive changes and subsequent shedding, must exercise a determining influence on our estimate of the physiological and pathological conditions of the skin, at all times, and must, in our opinion, be universally allowed for, and, therefore, that a careful investigation of the environment and history of pathologically developed skin features will generally reveal the sources of such phenomena, with the means of their obviation, and removal; therefore, it behoves all engaged in dealing with such matters to differentiate between the textural elements of the skin tissue involved. Thus, its various vascular elements particularly, as well as its so-called solid histological elements, must be individually and collectively examined in each case, so that the order and sequence of the pathological changes may be correctly appraised, in preparation for the most rational prescription of the requisite treatment for their removal being indicated (by the series of pathological phenomena characterising the condition) on the most scientifically indicated principles.

If the pathological condition be found to be due to blood circulatory causes, then it will follow, as a histological corollary, or necessity, that the treatment should be

directed to the restoration of the physiological condition, or *status quo ante*, by the adoption of remedies which appeal to the proper blood elements, as well as to their containing and circulating vessels. If, on the other hand, the neuro-vasculature and its contained nervine elements be the primary, or main, cutaneous element involved in the pathological process under observation, then it will, equally necessarily, follow that an appeal must primarily be made to the neural economy of the skin, and here it may be asserted that it will, in the large majority of cases of skin disease, be found that they originate in nervine influences, and by degrees, or secondarily, involve the blood vasculature and other structural elements of that great compound anatomical development of superficial protection and sensory organism. As a matter of fact deducible from daily observation, we think it will be found that this large proportion of nervine cutaneous ailments is traceable, to a great extent, to faulty epidermic exfoliation, to sudoriferous stasis, to aggravated, or chemically perverted excretion, or to bacterially septic conditions of the outflowing fluid.

As typical examples of cutaneous disease owing to these neuro-cutaneous conditions, we would cite, hyper-keratosis—over-dry and thickened skin—variola and the exanthemata generally. The first mentioned is a disease due to aggravated, or retained, epidermal exuviation, and is caused by interference, directly and indirectly, or both, with the economy of epidermal disintegration, such interference being due to increased consistency of the epidermal exuviæ, from aggravated cement element, or to hindered shedding, from absence of the disrupting influence of moisture, consequent on a repressive environment, or a deficient sweat excretion, or outflow. The second mentioned is usually due to the same causes, minus the operation of the influences of epidermal accretion. While the third mentioned is modified by the outflow of a bacteria-laden cerebro-spinal fluid, impregnated and intoxicated, within the cerebro-spinal cavity, with a specific microbe, the outflow and release of which constitutes the familiar marking of the long debated disease small-pox. The exanthemata generally conform, in their main features, to

variola, being determined on similar lines, but differentiated, through specific differences in the habits and character of their respective bacterial causes, each developing its specific features, in accordance with the growth and life-history of its own peculiar bacillus, thus unifying and diversifying the "methods and manners" of this category of morbid entities with a chameleon-like character, as singular, and manifold in its manifestations as the "natural history" of its origin necessitates and determines. The almost infinite variety of skin eruptions, or, at anyrate, that portion of them which owes its origin to microbic organisms, may be grouped with the more definite class of the exanthemata proper, with advantage to scientific accuracy, and with the added likelihood of having their treatment more rationally indicated, than when considered separate morbid entities, devoid of "natural history" affinities, and with altogether specific characters.

The phenomena of pathological cuticular exfoliation and epidermic shedding thus become a key to unlock many of the secrets "lying hid" on the very surface of humanity, and presenting the most familiar, as well as conspicuous, marring features, which it is daily made aware that it possesses, and which call aloud unceasingly for removal, on the grounds of personal self-respect, as well as æstheticism, and the *creation, not survival, of the fittest*.

The phases through which the normal cuticular exfoliation passes, in the lives of the longest livers, constitute *an unbroken record* of developmental evolution of the most exact description, physiologically and histologically speaking, which it is possible to observe throughout animated nature, vegetable and animal, but its study has, we think, not been given that exact and exhaustive attention which its importance, as an instrument of utilitarian importance, in medical, medico-legal and purely scientific affairs, entitles it to. We would, therefore, bespeak for it, the consideration, in these various aspects, which that importance warrants. Moreover, its study has an attractiveness and repulsiveness, so to speak, in the popular mind, which, if properly directed, may yield results, fruitful of benefits to the world at large and provocative of individual, as well

as communal, effort, in personal æsthetics and hygiene, which will amply repay both the individual and the community, in both these aspects of this most important and all-pervading subject—its reward being ultimately realised and expressed in the ability to appreciate the word, *circumspice*.

As we have, elsewhere, endeavoured to show that every period of the life of the individual human being is characterised by certain external, or cutaneous, appearances, it will be sufficient here to recapitulate that infancy, youth, middle life and age, are stamped with such indelible and unmistakable features that they are evident to the “man in the street,” and that it is generally found unnecessary to put a question to the subject of observation in order to test the truth of “the first impression.”

These “tell tale” appearances usually involve the whole textures of the skin, and are evolved by the incidence of certain specific and constantly occurring histological changes which fundamentally alter the proportions of these textures in their relationship to each other, as well as to the subjacent non-cutaneous tissues. The very unusual expediting, or retarding, of these normal cutaneous changes, should, therefore, be a warning to the clinician, when called to give a pathological reason for their occurrence, and should put him on his guard against coming to “rash conclusions” and unjustified suspicions, notwithstanding that he may have some claim to be adjudged a “Sherlock Holmes.”

We are persuaded it will be found that the great determining cause of these cutaneous changes is the altering relationship in arrangement and proportions of the two neural elements of the skin, the sympathetic and the systemic, and of the involved blood vasculature, these changes occurring in regular and rhythmic manner, in accordance with the conditions, and requirements, of the ages, or stages, of life—the sympathetic nervature predominating at the, earlier and later stages, and the systemic at that stage when the proper work and functions of life are being daily taken part in, or when the “battle of life” is being daily waged. Thus, in infancy and age, the predominance of the sympathetic and reflex nerve

phenomena, due to the undeveloped and the dismantled condition of the systemic nervature, respectively, is in strict accordance with the functional necessities and nervine requirements, at these periods of life, while in that period of life involving the incessantly, the acutely, and the intelligently, controlled exercise, of the voluntary, or systemic, nervature, with its connected non-nervous structures, or tissue elements, strictly accordant skin changes likewise ensue. As an example of the regular and rhythmic sequence of developmental changes, in one feature of cutaneous surface appearance, we would call attention to the "ridge and furrow" markings (Fig. 70),

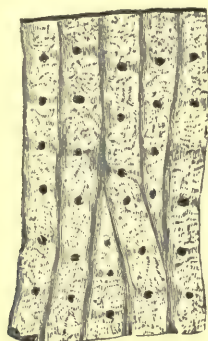


FIG. 70.—MAGNIFIED VIEW OF FOUR OF THE RIDGES OF THE EPIDERMIS, WITH SHORT FURROWS OR NOTCHES ACROSS THEM: ALSO THE OPENINGS OF THE SUDORIFEROUS DUCTS. (After Breschet.)

of the palmar and plantar surfaces of the terminal phalanges, as well as general palmar and plantar surfaces of the hands and feet. These markings, especially of the fingers and toes have, for a long time, attracted the attention of both the lay and the expert observer, and, to some extent, advantage has been taken of the information so gained for purposes of medico-legal and other enquiries; such being the case it, therefore, behoves us to eliminate sources of error from our reading of them, and to place, if possible, on a more exact basis, the information which is sought from them. Thus, according to our observations, it will be found that the original, or ground, plan, is adhered to, from histological necessity, throughout the greater part, but

not the whole, of life, while the depth of the furrows, and, consequently, the height of the ridges, undergoes a regular series of changes, according to the individual experience, as to employment, and the age reached—the greatest height of the ridges being reached during the period of most active employment, when the tactile susceptibility of the sensory nervature, or the “*tactus eruditus*,” has been fully attained, and, consequently, it will be found to synchronise with the greatest depth of the intervening furrows—except where local “tear and wear” interfere.

The reason for this will no doubt be found in the greater determination of the nervine nutritive elements from the central, or cerebro-spinal, neurons to the constantly and acutely active peripheral nervature of the digital terminal expansions and palmar surfaces. It will, consequently, be found that the infant has well-marked, but not conspicuously developed, ridge and furrow digital details, that the youth shows more decided development of these, that the adult reaches the climax of development, at the period synchronising with that age when the tactile sense is in continual and everyday erudite use, and that when the active age limit has been reached, the acutely delineated ridge and furrow markings begin to show signs of levelling down, which continue to grow until all that is left of them is a landmark, in the form of a fragmentary and belated ridge, or furrow, which at last merges into a smooth and even surface, polished by the hand of time into a uniform, thin and worn vestige, to contain and protect the crumbling body within, and to afford a tactile surface, sufficient to maintain a, more and more, restricted communication with the world without, as the diminishing necessities for intercourse with it cease and determine. It ought, here, to be mentioned that ridge and furrow markings survive longest on the surfaces of the skin of the thumb and forefinger, with, *perhaps*, part of that of the middle finger, which may be due to the manner of innervation of these surfaces, but which, we are strongly of opinion, is also partially due to the continuous necessity for the passage of nerve impulses through these digits in particular, and

the consequent greater determination of nervine material to their terminal tactile organs.

A like fate befalls the appendages of the skin, during the passing of the stages of life, the hair of the head, and face, especially, from its conspicuous position, showing the markings of the passage of time so clearly and definitely as to become, in reality, a personal historical narrative, "known and read of all men"; this fate being due to the operation of the same physiological laws and factors which determine the general cuticular growth and decay. Depending on the operation of the same somatic, or developmental, factors, is the disappearance of much of the subcutaneous tissue from the digital extremities, so



FIG. 71.—COMPOUND PAPILLAE FROM THE PALM OF THE HAND. Magnified 60 diameters.

a, basis of a papilla; *b*, *b*, divisions or branches of the same; *c*, *c*, branches belonging to papillae of which the bases are hidden from view. (After Kölliker.)

that the plump well-filled appearance usually characterising the ends of the fingers gives place to one more or less shrunken, with, consequent, wrinkles, running parallel with the bones and tendons. These markings, it need scarcely be said, begin to supersede the original ridge and furrow markings, and ultimately usurp their position, producing a more or less completely new system of markings, necessitating the alteration, if required, of any early medico-legal negative, which may have been taken, in the case of the aged criminal, or others, who take an innocent interest in these matters of personal appearance.

Pursuing the subject more generally, it becomes apparent that we have, in the study of the evolution of skin changes and phenomena, physiological and pathological, a subject, having an independent bearing of very large proportions which calls for a broad general, as well

as special, attention, while we also perceive, that its bearings on the subject of the body generally requires to be pursued with an eye to the reaping of whatever utilitarian advantages it can afford, in indicating, especially, the lines along which medical and surgical art can proceed with the greatest hope of success, in the treatment of disease, the maintenance of health and the rectification of faulty structure.

The skin, moreover, being to a great extent structurally, as well as functionally, entitled to rank as an organism, separate from the proper body structures and organs which it encloses, with special duties to perform, and a protective régime to fulfil, we must be prepared to find, in and on it, much of independent pathological change, dependent on merely local conditions, and much due to its connection with the proper body structures, and organs, and, therefore, much time and effort will have to be spent, in the tracing of inter-relationships and inter-dependencies of superficial and deep-seated disease, respectively, in order that these skin affections may be traced to their sources and appropriate curative, as well as preventive, measures, be adopted. In this regard, we repeat, that these sources will very, indeed, most frequently, be found in, and to emanate from, the central nervous system, with its surrounding layers of cerebro-spinal fluid, where the required facilities for the entrance, accumulation and spread of chemical and bacterial morbid agencies abound, and whence also the requisite distributive media are supplied, ready to hand, in the continuous, inter-meningeal and inter-neurilemmar spaces of brain, cord and nerves which ultimately debouch within and on the surface of the skin, throughout its entire extent.

It ought here to be added that the study of the incidence of skin disease as thus viewed, sheds a "comparative" light, of a most illuminating character, on the incidence of disease, as it manifests itself in the motor aspect of the systemic nervature, and in the compoundly innervated structures of the various viscera, and internal membrane invested cavities of the body; thus, to mention but one instance of the occurrence of bacterio-pathological

sequence, viz. the, so-called, malignant endocarditis, we observe, the invasion of the cerebro-spinal cavity with the germs of the pneumococcus, the subsequent invasion by continuity, through the neurilemmar passages, and interspaces of the pneumogastric nerves and structures of the heart, and the growth there of broods of the microbe, originally reared in the medium of the cerebro-spinal fluid. We might cite other instances, but let this suffice to attract that notice which, we contend, the intrinsic value of the subject, in enabling us to affiliate and differentiate morbid entities, entitle it to.

Moreover, we are convinced, so far as our application of this key, to the opening up of new problems, has enabled us to do, that a great future is in store for its study, in clearing up many obscure and impenetrable regions of seemingly disconnected, but related, morbid phenomena, and indicating a more scientific, and less empirical, manner, of their treatment, preventive, curative and ameliorative.

Furthermore, here we find, ready to hand, a rational explanation of the paradoxical phenomena of metastasis and kindred pathological occurrences so frequently to be met with in the experience of every clinical observer.

EXTRACT XXI. A.

ON THE STAGES OF EVOLUTION OF THE HUMAN ORGANISM, DIVIDED INTO UNICELLULAR, BLASTODERMIC, OR MULTICELLULAR, NEURENTERIC, AND VISCERO-SKELETAL.

THE sequence of formative events, embraced in the above series, comprises the whole of the evolutionary stages of human organic life, which, when regarded in conjunction with the involutionary stages of that life,

FIG. 72.

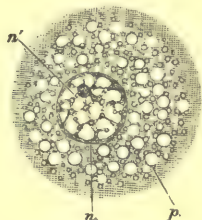


FIG. 72.—DIAGRAM OF AN ANIMAL CELL MUCH MAGNIFIED. (E. A. S.)

p, protoplasm, with vacuoles and granules; *n*, nucleus, with intranuclear network and nucleolus (*n'*).

FIG. 73.

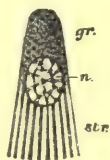


FIG. 73.—STRIATED EPITHELIUM CELL, FROM THE DUCT OF A SALIVARY GLAND; HIGHLY MAGNIFIED. SEMI-DIAGRAMMATIC. (E. A. S.)

gr, granular protoplasm; *str*, striæ; *n*, nucleus.

constitute the whole “span” of its existence. The phenomena embraced in each and every stage of human, in common with all other, life are the outcome of physico-dynamic agency and specific, or vital, formative impulse, embraced in and transmitted from parent, to

offspring, modified by environment, and again transmitted, in turn, to a succeeding generation, with attributes, and characteristics, secured, to perpetuate the species, and maintain its ascendancy, as an evolutionary instrument. Transmitted, or inherited, nervine energy, which is here equal, or equivalent, to vital energy, is the dynamic agency and formative means by which lifeless matter is converted into living protoplasm, fashioned into organic form and endowed with separate, and independent, existence, fitting it to perform its specific functions, as a living unit, in the long life roll of organic forms. That energy, while vitalising, and organising, the primordial

FIG. 74.

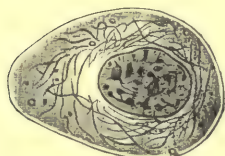


FIG. 75.

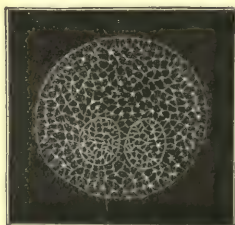


FIG. 74.—A CARTILAGE CELL OF THE SALAMANDER, SHOWING FINE FILAMENTS IN THE PROTOPLASM. (Flemming.)

FIG. 75.—DIAGRAM OF AN ANIMAL CELL (WITH TWO NUCLEI). (Klein.)

cell (Figs. 72, 73, 74, 75) protoplasm, is operated by molecular nervine machinery, destitute of the proper histological elements of a nervous system, but, nevertheless, by a system of dynamic production, storage and distribution, absolutely effective in innervating, and meeting the vital requirements of the unicellular organism, and of the individual dynamic cell wants of the communal cell organism (Figs. 76, 77), as it exists in the human organism previous to the evolution of the sympathetic nervous system, and as it exists in every cell unit, of the communal cell organism, each of which cells continues to be thus individually innervated throughout its entire life-history.

Nerve energy, or force, may, therefore, be, nay must consist, so far as analogy warrants the statement, of a

conversion of one, or more, of the ordinary forms of energy, or force, into that of nerve energy, or force, by the transmitted potentialities of the fecundated ovum, or primordial germ, and so long as that process of dynamic conversion can be continued, so long will the life of the cell, and the multicell, organism, be maintained, and the great function of innervation be effective, as the vitalising, and formative, medium, dynamically, and physically, in parent, and offspring, alike; each generation being but

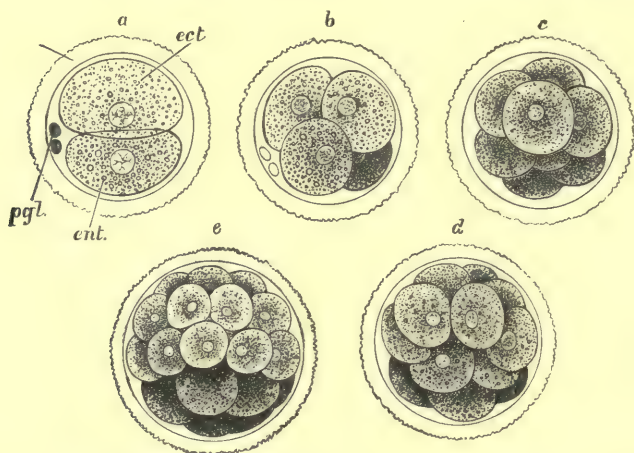


FIG. 76.—FIRST STAGES OF SEGMENTATION OF A MAMMALIAN OVUM; SEMI-DIAGRAMMATIC. (Drawn by Dr. Allen Thomson, after Ed. v. Beneden's description.)

z.p., zona pellucida; *p.g.l.*, polar globules; *ect.*, ectomere; *ent.*, entomere. *a*, division into two blastomeres; *b*, stage of four blastomeres; *c*, eight blastomeres, the ectomeres partially enclosing the entomeres; *d, e*, succeeding stages of segmentation showing the more rapid division of the ectomeres and the enclosure of the entomeres by them.

a repetition of another, in unbroken succession and order, even from the "original departure" of organic, from inorganic matter, under the vital, and formative, influence, of the original cosmic energy, plus "the creative" stimulus and the subsequent continued conversion of that cosmic energy into vital energy, or life.

Protoplasm, as it is now technically called, was, or is, the first living, or independently existent, organic material, and the materio-dynamic basis of the whole life forms of the globe, wherein are fashioned and organically evolved its entire flora and fauna, by the formative impulse

given to its "first created" particles, and transmitted to individual organised entities.

After, and out of, protoplasm, are elaborated the individual organic units known, as cell (see Fig. 72), and multi-

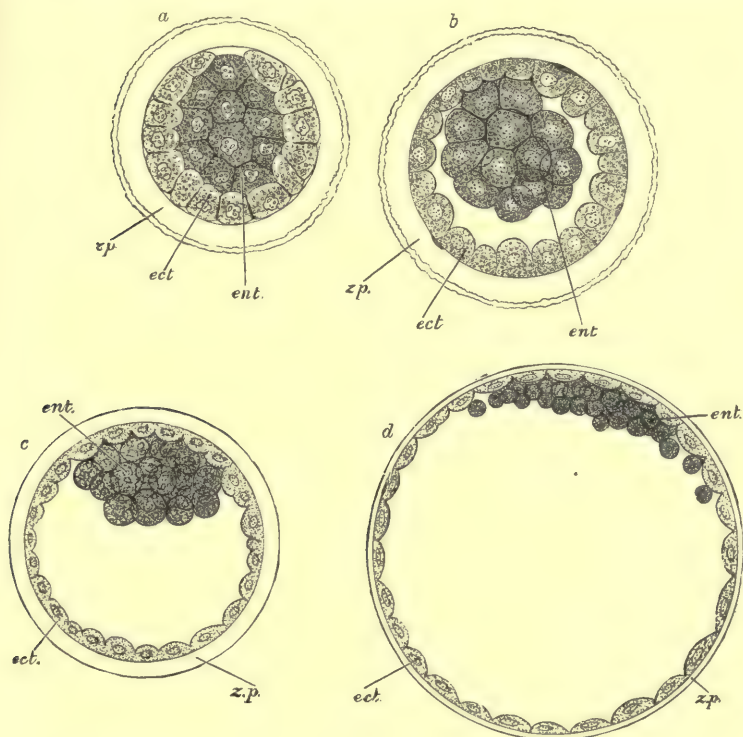


FIG. 77.—SECTIONS OF THE OVUM OF THE RABBIT DURING THE LATER STAGES OF SEGMENTATION, SHOWING THE FORMATION OF THE BLASTODERMIC VESICLE. (E. v. Beneden.)

a, section showing the enclosure of entomeres by ectomeres except at one spot—the blastopore; *b*, more advanced stage in which fluid is beginning to accumulate between entomeres and ectomeres, the former completely enclosed; *c*, the fluid has much increased, so that a large space separates entomeres from ectomeres except at one part; *d*, blastodermic vesicle, its wall formed of a layer of ectodermic cells, with a patch of entomeres adhering to it at one part; *z.p.*, *ect.*, *ent.*, as before.

cell (see Fig. 76), creatures vegetable and animal, whose vital energy, or life, although indistinguishable from nerve energy, is molecularly generated, stored and operated, without the intervention of a nervous system properly so called, but, necessarily, a molecular, or non-cellulo-fibral, nervous system; indeed, in the multi-cell creature, a

fibril nervous system, so to speak, is established, as the primordial, or original, cell undergoes mitosis, whereby, every added cell continues correlated to, and innervated by, that cell, or the communal, or multi-cell, centre, through the connected, or inter-cell processes, left by, and maintained in, structural continuity with the various sections of the mitosing cell, cells, and cell groups, to their peripheral boundaries, or to their full structural extent (see Fig. 77).

From this point, in the process of evolution of the nervous system proper, as the vital activities and necessities of living things increase, and the conditions of independent existence become more complex, it is observed that vital energy is allowed to "play at large" less and less, and that channels, strands, or filaments are

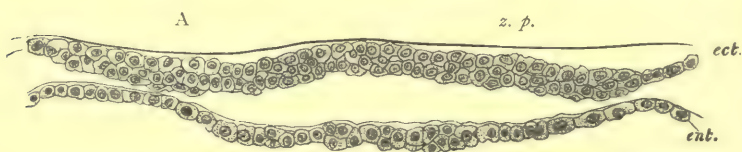


FIG. 78.—A. SECTION THROUGH PART OF A BILAMINAR BLASTODERM OF THE CAT. (E. A. S.)

ect., *ent.*, ectoderm, entoderm; *z. p.*, thinned out zona pellucida.

provided, along which it can pass with greater ease and precision, and through which it can be operated by central control, according to the dynamic necessities of the individual structural elements of the increasingly complex organisms. Here, we see the origin and evolution, or development, of the first great nervous system so called, viz. the sympathetic nervous system (Fig. 78). From our earlier remarks on nerve energy, or life, we might, however, correctly call the sympathetic nervous system the second nervous system, inasmuch as the uni-cell organisms are kept alive, or innervated, by molecular continuity and intra-cell connective processes, and, therefore, by "*a nervous system*," and, of necessity, the *first nervous system* connected with the living protoplasm and primary organisation of living forms generally. While this is, no doubt, correct, for convenience' sake, we shall entitle the sympathetic nervous system the first great

nervous system, or, in other words, we shall include under the title of the first great nervous system, both of the systems, the intermolecular and intercellular (see Figs. 72, 78). As the unicellular organism cannot live apart from its innervating mechanism and energy, and, in fact, the cell organism and its innervating mechanism and energy are one and indivisible, it becomes necessary to regard every such organism as a nerve unit, consisting, or composed, of living matter and energy, or, in other words, a living form, whether it be in a unicellular, or multicellular, condition.

No cell, being able to live apart from nerve energy and mechanism, and each cell of a multicellular organism, being regarded as a nerve unit, we must conclude, that each of those cells is a component part of one, or the other, nervous system, and that, therefore, every cell of the human body, apart from the systemic nervous system, by whatever name known to science, is a sympathetic nerve cell, innervated by, and functionally operated from, that system, thus obviating vital inconsistencies and material and dynamic, overlapping, or redundancy. Thus is insured centralisation for functional purposes, or administration, and individual cell freedom, as well as communal control and association of vital effort, in concerted work, and co-operative intention, and performance.

The individual sympathetic nerve cell is operated by molecular nervous machinery, while the communal cell groups are operated for communal ends, by inter-cell connective processes, developed and left by the original cell mitosis, and adapted for the transmission of nerve impulse, from cell to cell, and from cell group to cell group, the required energy for the higher wants of communal innervation being produced, stored and distributed, by the ganglia developed throughout the length and breadth of the sympathetic nervine area, and, perhaps, to some extent, borrowed from the systemic nervous system, and received through its communicating branches, from the associated systemic centres of production and distribution.

The sympathetic nervature, besides the offices already mentioned as peculiarly its own, fashions and evolves the most highly organised and functioned structure, known

to science, viz. the systemic nervous system, and sustains it materially and dynamically, so that it can perform neural functions, of an order altogether unknown to the sympathetic nervous system itself, as well as a higher order of functional work known as psychic, which brings the human being into relationships outside itself, in a way altogether transcendental and *sui generis*, and thereby gives it views of itself, and the surrounding universe, which blend with and finally bring it into intimate relationship with, the great First Cause, of which it discovers itself to be but the organic effect and the conscious product, although the highest order of evolutionary effort,

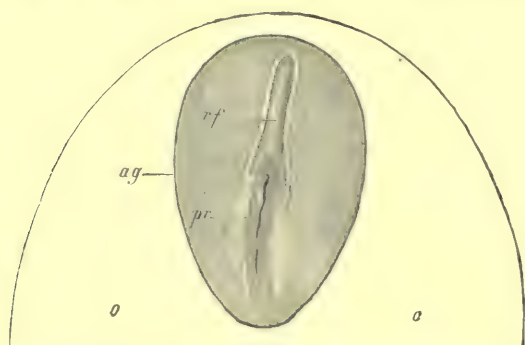


FIG. 79.—EMBRYONIC AREA, WITH OUTLINE OF THE VASCULAR AREA, FROM A RABBIT'S OVUM OF SEVEN DAYS. $\frac{2}{3}$ (From Kölliker.)

co, vascular area; ag, embryonic area; pr, primitive streak and groove; rf, medullary groove.

and, at present, the only representative of deeply rational and moral being.

The systemic nervous system, being the most highly organised and functioned, structure in the human body, is made capable of bridging over the gulf fixed, between merely organised matter, and life, and the psychic, or purely cerebro-dynamic, phenomena, and effecting a union, between the inorganic matter of the cosmos, which is connected with the organic life of the globe, on the one hand, and the ultra-cosmic universe on the other, which reaches from the illimitable and eternal, in the past, to the illimitable and eternal, in the future, and represents the progress so far as it has yet reached, of the process of evolution, which has now become a great working theory,

by which we are enabled to trace the sequence of events in the past, and dimly to perceive the probable trend of events in the future.

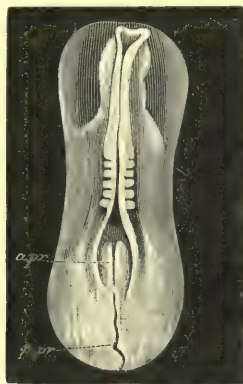


FIG. 80.—DORSAL VIEW OF A BLASTODERM AND EMBRYO CHICK HAVING FIVE MESOBLASTIC SOMITES. (From Balfour.)

a.pr., anterior part of the primitive streak; *p.pr.*, posterior part; the medullary ridges have come together in the greater part of their extent, but have not yet united; the caudal swellings are visible on each side of *a.pr.*

The systemic nervous system is evolved, from the ectodermal division of the sympathetic (Fig. 79), nerve area, by the growth and involution, of the dorsal segment

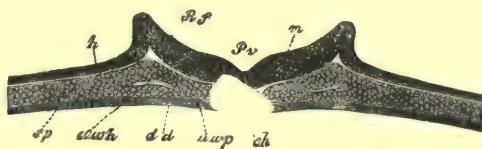


FIG. 81.—TRANSVERSE SECTION THROUGH THE EMBRYO OF THE CHICK AND BLASTODERM AT THE END OF THE FIRST DAY. Magnified from 90 to 100 times. (From Kölliker.)

h, epiblast; *dd*, hypoblast; *sp*, mesoblast; *Pv*, medullary groove; *m*, medullary plates; *ch*, chorda dorsalis; *uw*, proto-vertebral plate; *uw*, commencement of division of mesoblast into its upper and lower laminæ; between *Rf* and *h* are the dorsal laminæ or ridges which by their approximation close in the medullary canal.

of the blastoderm (Fig. 80), and to some extent invades, and innervates its hypodermal, or ventral, segment, from which it becomes ultimately differentiated, but not absolutely separated, thereafter; its further evolution, and distribution to the mesodermal (Figs. 81, 82, 83) and hypodermal areas, being secured by elongation of its

axonal cell processes and the inter-penetration and blending of their structural elements, with ultimate intimate union of their respective terminal nervine extensions, and, consequent complete innervation, unal and dual,

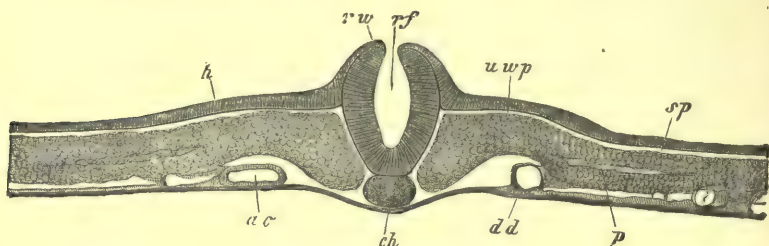


FIG. 82.—TRANSVERSE SECTION OF AN EMBRYO CHICK IN THE LATTER HALF OF THE SECOND DAY, AT THE PLACE WHERE THE VERTEBRAL SOMITES CEASE. $\frac{3}{1}$ (From Kölliker.)

rw, dorsal ridges; *rf*, medullary groove or canal beginning to close; *uwp*, proto-vertebral plate; *sp*, lateral plate of the mesoblast; *h*, epiblast; *dd*, hypoblast; *ao*, primitive right aorta; *ch*, commencement of division of the mesoblast which forms the body cavity.

single and combined. At this stage of the organic progress of evolution of the human organism, the most notable feature is the neurenteric canal (Figs. 84, 85), which is most happily named, as it is a canal in every sense

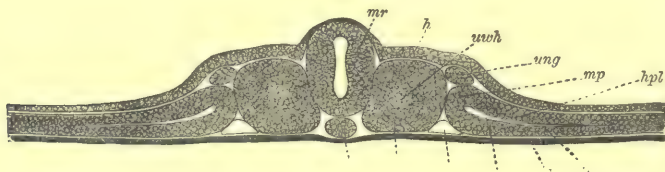


FIG. 83.—TRANSVERSE SECTION THROUGH THE EMBRYO OF THE CHICK AND BLASTODERM ON THE SECOND DAY. (From Kölliker.)

dd, hypoblast; *ch*, chorda dorsalis; *uw*, primordial vertebræ; *mr*, medullary plates; *h*, corneous layer or epiblast; *uwl*, cavity of the primordial vertebral mass; *mp*, mesoblast dividing at *sp* into *hpl*, parietal, and *df*, visceral laminæ; *ung*, Wolffian duct beginning in the intermediate cell-mass.

of the word, and contains a common fluid, stretching from the buccal cavity to the anterior vesicle, or rudiment of the future brain, with an unbroken lumen and continuous walls. It is V shaped, becoming open at its buccal end, and closed at its cerebral vesicular termination, its two halves becoming differentiated and partially separated, at the posterior extremity of the V, and united by anasto-

mosis at their anterior extremities through the junction of the buccal diverticulum with the infundibulum in

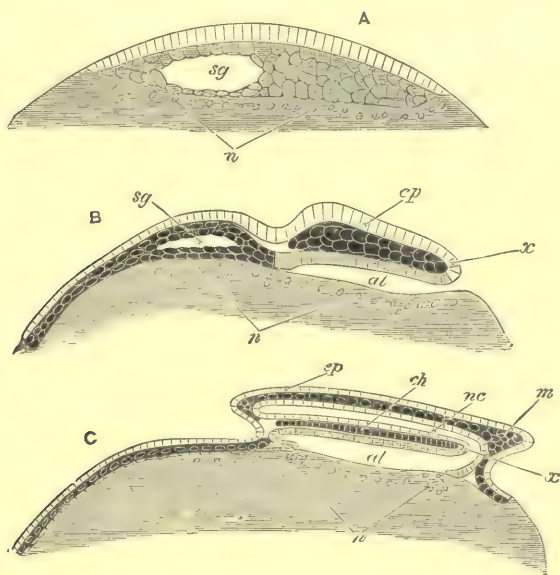


FIG. 84.—DIAGRAMMATIC LONGITUDINAL SECTIONS OF ELASMOBRANCH EMBRYO AND BLASTODERM. (From Balfour.)

A, younger stage with two primary layers; B, more advanced stage with three layers and invagination at the hinder end of the embryo; C, still more advanced; the embryo raised from the blastoderm with neural and primitive alimentary canals and neurenteric communication between them.

ep, epiblast; *m*, mesoblast; *x*, epiblast continuous with hypoblast; *nc*, neural canal; *ch*, notochord; *al*, alimentary cavity; *sg*, segmentation cavity; *n*, nuclei of the yolk.

the matrix of the hypophysis, the anterior and posterior, lobes of which uniting elements respectively, constitute

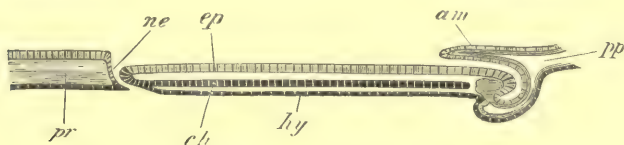


FIG. 85.—DIAGRAMMATIC LONGITUDINAL SECTION OF AN EMBRYO OF LACERTA. (From Balfour.)

pp, body cavity; *am*, amion fold; *nc*, neurenteric canal; *ch*, notochord; *hy*, hypoblast; *ep*, epiblast of the medullary plate; *pr*, primitive streak. In the primitive streak all the layers are partially fused.

the developmental basis, the processes, of posterior neurenteric differentiation, and anterior neurenteric union,

taking place simultaneously, and, so, maintaining a persistent, continued, but modified continuity, of the two divisions of the canal.

After this simultaneous separation and reunion of the canal, its anterior limb becomes the alimentary, while its posterior limb becomes the neural, canal, each of which canals continues to perform the functions of a canal, and to keep up a modified connection with each other, in the performance of their respective, but absolutely different, functional (Fig. 87) rôles.

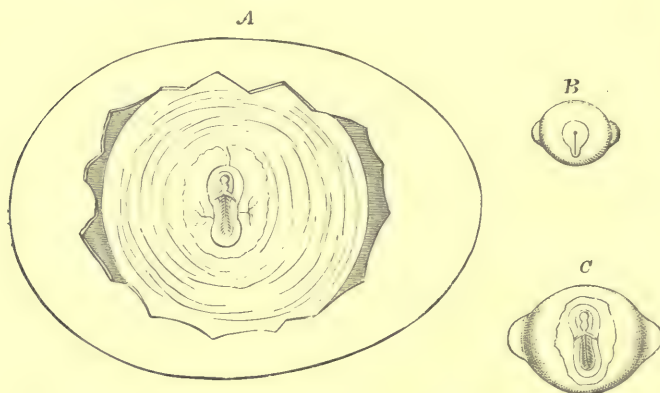


FIG. 86.—OUTLINES SHOWING THE RELATION OF THE AXIS OF THE EMBRYO TO THE OVUM IN BIRDS AND MAMMALS. (A. T.)

A, Fowl's egg opened after 35 hours' incubation, showing the embryo chick within the transparent and vascular area, on the surface of the yolk; at right angles to the long axis of the egg; B & C, two early stages of development in the ovum of the dog, showing the primitive streak (in B) and the commencing embryo (in C); the line of the uterine tube and long diameter of the ovum being at right angles to the vertebral axis of the embryo.

The alimentary canal remains an open canal, secured at its extremities by mechanisms of entrance and exit, to provide for the reception, retention and residuum disposal, of the alimentary materials supplied to the body; while the neural canal, receives into its own central cavity, along with the intra-spaces of its peripheral tributaries the systemic nervous system comprised of, brain, cord and nerves, providing a great fluid surrounding and interpenetrating space, in which all these neural elements can float, secured, and insulated, from centre to periphery, and from periphery to centre.

The alimentary canal is provided with a series of locks,

among which, gastro-enteric areas, for general, as well as special, treatment of the alimentary materials, are provided, and thus, follow each other, the oral lock, the pharyngeo-œsophageal, the cardiac, the pyloric, the ileo-cæcal, the sigmoid, and the anal, locks, with the intervening digestive spaces, the oro-pharynx, the œsophagus, the stomach proper, the duodeno-jejuno-ileal intestine, the cæco-colonial bowel and the rectum. Each of these canal divisions, or digestive areas, is provided with a series of

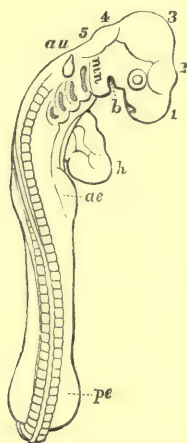


FIG. 87.—OUTLINE OF THE EMBRYO-CHICK AT THE END OF THE THIRD DAY, TO SHOW THE INFLECTIONS OF THE BODY AND THE COMMENCEMENT OF THE LIMBS. (After His.)

1 to 5 the cerebral vesicles; *b*, the mouth; *mn*, the lower jaw, and behind that the branchial bars and clefts; *au*, the auditory vesicle; *h*, the heart; *ae*, anterior extremity; *pe*, posterior extremity; the hinder part of the body is still prone upon the surface of the yolk, the head is now lying on its left side and between is seen the gradual torsion of the vertebral column and trunk.

secretional fluids, and more or less absorptional machinery, whereby the prolonged and complicated process of digestion, is fully effected, and the irreducible residuum returned to the outer world. We may take it, moreover, that each of these digestive stages represents a specific form of digestion, in which certain alimentary articles are treated, and that the whole of them are required, to meet the necessities of a complex digestive process, such as, undoubtedly, is present in man. The oro-pharyngeal digestion may be described as preparatory, but most important, in that the saliva from six different glands,

and the glosso-pharyngeal muco-colloid excretion are intimately mixed with the pristine alimentary materials, on some of which they must immediately act, while, on others, they may subsequently exert a digestive influence. The œsophageal digestive influence, must consist of admixture with the local mucous discharge, and what mechanico-chemical change is effected in transit to the stomach. The gastric digestion is a long, and complex process, combining the effects of mechanical, chemical, and physiological, influences, and culminating in removal, by absorptive agency, of a considerable portion of the alimentary material, while the duodeno-jejuno-ileal digestion, from the extent of surface passed over, and the many fluids mixed with the chyle during its prolonged transit, must be of scarcely less importance than that of the stomach, although the articles of food digested differ in chemical, and other characteristics, from those dealt with in the stomach. In both these digestions the dynamic agencies at work comprise mechanical, chemical and physiological, acting singly and in combination, in ordinary, as well as, specific manner, and having the effect of securing the absorption of a large proportion of the principal elements of the food, before their passage through the ileo-cæcal valve. The cæco-colonial digestion differs very much from the preceding digestions, inasmuch as the alvine contents now become stercoraceous, and can yield for nutritive purposes a lesser quantity, and a somewhat peculiar quality, of digested material, the digestive agencies here, are the same as in the preceding, plus, it may be, the disintegrative, and specific, influence, of bacterial organisms, or living dynamics, in the form, for instance, of the anaërobic *bacillus coli*. Following the cæco-colonial, is the final stage, of digestion, the rectal, which is separated from the cæco-colonial by the mechanical obstruction, or pseudo-valve, effected by the sigmoid flexure, and which may be regarded, as the inner sphincter, or a safeguard for the *sphincter ani*. In fact, the sigmoid flexure may be regarded as possessing the function of fæcal meter, or fæcimeter, if we may use the term, allowing to pass only what is meant for prospective evacuation, and retaining behind what is yet fit to afford further nutriment. Consequently, we may regard the

rectal digestion, as bereft of almost all the attributes of a digestive process, although, from clinical experience, we have learned, that even the rectal mucosa is capable of absorbing ready-prepared nutritive matter, and can be relied upon to do so in certain suitable emergencies.

The enteric canal, thus, remains patent, or hollow, and, passes through it the food which is to serve for the nutriment of the body, the compartments, into which it is divided, serving for specific parts of the digestive process, and the absorption, of specific elements of nutrition, by the various local mucosæ. Many of the glands, and a number of the principal viscera, empty themselves into it, adding digestive elements, and excreting, it may be, certain effete matters, for removal from the body.

At its interior and posterior, extremities, it is in a modified form, still connected with its former neural half, and affords a means of exit for the disposal of super-abundant cerebro-spinal fluid, which continues to represent the fluid with which it was originally occupied, and which it continues to utilise both for mechanical and physiological, purposes.

The neural half of the neurenteric canal, is almost completely occupied, as we have already said, by the systemic nervous system, which has grown into it, and then pushed before it, by every axonal fibre, or process, which grows out of it, a continuation of its meningeal coverings, into every hole and corner of the body, innervated by that system, as a protection, or inhibiting wall, in the form of neurilemma and perineurium, or meningeal continuation.

The neurally unoccupied part of the canal, is, therefore, represented by the ventricles of the brain, the central canal of the cord, the sub-arachnoid and sub-dural, spaces, centrally, and by the intra-neurilemmar spaces of the nerves, peripherally, all these spaces, being continuous, the one, with the other, and all occupied by the cerebro-spinal fluid, the representative of the original neurenteric fluid, which occupied the undifferentiated neurenteric canal.

The systemic nervous system, has, therefore, projected itself, along the lines of least resistance, into the mesodermic, and hypodermic, areas of the body, becoming

invaginated, by meningeal continuations, throughout its entire extent, thus securing for itself, effective mechanical protection and support, continuity of proper nervine elements and complete structural isolation, and functional, or dynamic, insulation, so constituting itself the great neuro-dynamic instrument and agency, in the human organism, throughout its systemically innervated extent.

The visceroskeletal stage of development and evolution, is represented by the formative process, of surrounding the alimentary segment of the neurenteric canal, with organs, and structures, fitting it for the performance of the digestion, aëration and distribution, of the alimentary materials, to suit the wants of the whole organism and providing an osseous casing for the central nervous system, consisting of brain and cord, and an osseous skeleton, whereby the voluntary musculature is enabled to effect locomotion, and through that, the manifold activities of a living and responsible existence.

This short recital gives, in brief, but recognisable outline, the salient features of the process of evolution through which the human body passes, before it begins its downward, or involutionary, course, or when aging begins to make itself felt, and to proclaim itself in every feature.

EXTRACT XXI. B.

ON THE DEVELOPMENTAL EVOLUTION OF THE HUMAN ORGANISM.

EVOLUTION is now generally adopted, as the best *working theory* in science building, so to speak, and the *line of progress*, to which all advances of truth and all tentative attempts at systemising knowledge should conform, in

FIG. 88.

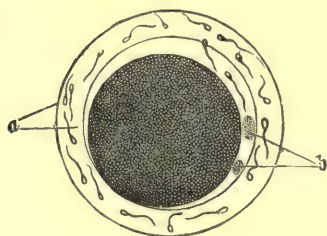


FIG. 89.

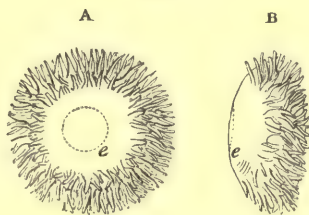


FIG. 88.—OVUM OF THE RABBIT FROM THE FALLOPIAN TUBE, TWELVE HOURS AFTER IMPREGNATION. (From Bischoff.)

In the zona *a*, spermatozoa are seen; *b*, two hyaline globules or polar bodies within the cavity left by the shrinking of the yolk.

FIG. 89.—FRONT AND SIDE VIEWS OF AN EARLY HUMAN OVUM FOUR TIMES THE NATURAL SIZE. (From Reichert.)

This ovum is supposed to be of thirteen days after impregnation. The surface bare of villi is that next the wall of the uterus, showing at *c*, the opacity produced by the thickened embryonic disc. The villi covered chiefly the marginal parts of the surface.

order, that overlappings, and shortcomings, of related truths, may be obviated, on the one hand, and “made good,” on the other.

Regarding evolution, from this point of view, as an instrument of scientific progress, we would seek to take

advantage of its services, so as to place *in review*, before the "mind's eye," the manner and method of man's growth, from the "monad" to the "cosmos" of organic rank, by bringing forward, and naming in detail, a few of the outstanding genetic features of his evolutionary production, and mature being.

To begin with the earliest stage of his developmental evolution, we recognise in it the mutual amalgamation of

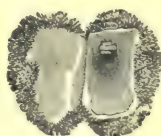
FIG. 90.

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FIG. 91.

A.



B.



FIG. 90.—HUMAN OVUM OF 12 TO 13 DAYS. (From Allen Thomson.)

1. The ovum of the natural size with simply villous chorion.
2. The same opened and magnified seven times. The large yolk-sac is seen with the embryo seen sideways lying flat upon the yolk-sac.

FIG. 91.—HUMAN OVUM AND EMBRYO OF ABOUT 14 DAYS.

(From Allen Thomson.)

- A. The ovum opened, half the chorion laid to one side and the embryo and yolk-sac seen in the other; natural size.
- B. The embryo and yolk-sac viewed from the dorsal aspect, magnified about ten times; *a*, yolk-sac; *b*, hind brain portion; here for a space the medullary canal is closed; *c*, the mid-brain open superiorly; *d*, hinder part of the medullary canal also open; *e*, portion of membrane, perhaps belonging to the torn amnion.

two, Adamic, or parental, materio-dynamic entities (Fig. 88), the vital union of which founds the future organism, and the survival of which, secures, and has secured, the continuity of the human race, from "its cradle," to its present generation and ensures its continuance into future generations. In this earliest stage of development are dimly visible, the working of the vital principles, which are to govern the future progress of developmental change, as well as, the method of unicellular life, which is continued as such, under the advancing stages of developmental progress, by cellular proliferation, and structural formation.

The cell, here, represents the most elementary mode of the operation of vital energy, in the conduct of the affairs of life, on the inorganic matter of nature, by which it becomes organic, and subservient to the requirements of metabolism, and capable of assuming, by formative law, the condition, by mitotic division and subdivision, of multicellular organisation which forms the second well-marked division of developmental evolution (see Figs. 76, 77). During this

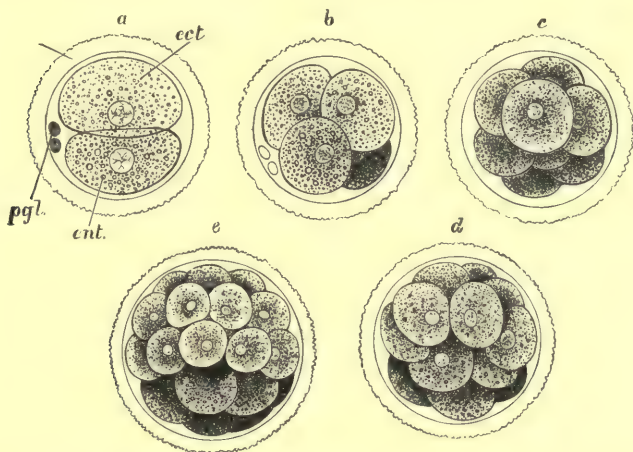


FIG. 92.—FIRST STAGES OF SEGMENTATION OF A MAMMALIAN OVUM; SEMI-DIAGRAMMATIC. (Drawn by Dr. Allen Thomson, after Ed. v. Beneden's description.)

z.p., zona pellucida; *p.gl.*, polar globules; *ect.*, ectomere; *ent.*, entomere. *a*, division into two blastomeres; *b*, stage of four blastomeres; *c*, eight blastomeres, the ectomeres partially enclosing the entomeres; *d, e*, succeeding stages of segmentation showing the more rapid division of the ectomeres and the enclosure of the entomeres by them.

stage, as the process of mitosis, or kariokinesis, advances, the proliferating cells assume the general structural form of blastoderm (Figs. 94, 95), which in turn assumes a, layered, or stratiform, arrangement, the precursor of a structural division, of the evolving embryonic mass. These blastodermic strata consist of the ectoderm, the mesoderm and the hypoderm, which, in continuing the developmental changes, lose their, more or less, parallel cellular arrangement, and assume the character of histologically formed structures, in which they ultimately become converted into the embryonic formation, known as the neurenteric canal and adventitial textures.

This developmental change, marks a great advance, on the preceding stages of embryonic evolution, and allows of the commencement of those further structural arrangements, which permit of the addition of the greatest materio-

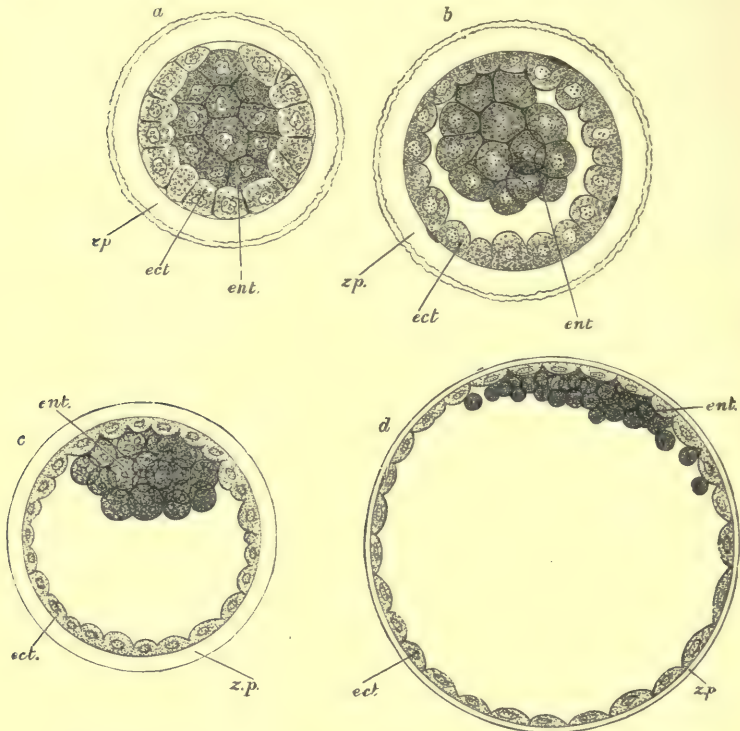


FIG. 93.—SECTIONS OF THE OVUM OF THE RABBIT DURING THE LATER STAGES OF SEGMENTATION, SHOWING THE FORMATION OF THE BLASTODERMIC VESICLE. (E. v. Beneden.)

a, section showing the enclosure of entomeres by ectomeres except at one spot—the blastopore; *b*, more advanced stage in which fluid is beginning to accumulate between entomeres and ectomeres, the former completely enclosed; *c*, the fluid has much increased, so that a large space separates entomeres from ectomeres except at one part; *d*, blastodermic vesicle, its wall formed of a layer of ectodermic cells, with a patch of entomeres adhering to it at one part; *z.p.*, *ect.*, *ent.*, as before.

dynamic change of all, a change in virtue of which, the whole embryonic structures become innervated by two related, independent, and co-ordinated, nervous systems, in addition to that unicellular innervation, which has continued to do duty since the unicellular amalgamation of the parental protoplasms, and which still continues sub-

servient to the materio-dynamic necessities of the two great nervatures.

In virtue of these latter additions to the mechanisms, and agencies of embryonic life, further developmental progress follows, with constantly increasing degrees of advancement in structural complexity and functional attainment, comprising the rudiments of the brain, cord, and nerves, and a bond of union between these, and the presiding sympathetic nervous system, which, until now,

FIG. 94.

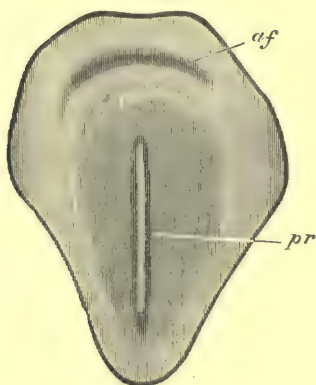


FIG. 94.—PYRIFORM TRANSPARENT AREA OF THE CHICK'S BLASTODERM WITH THE PRIMITIVE GROOVE.

pr, primitive streak and groove; *af*, amniotic fold commencing; the darker shading round the primitive streak indicates the extension of the mesoblast.

FIG. 95.

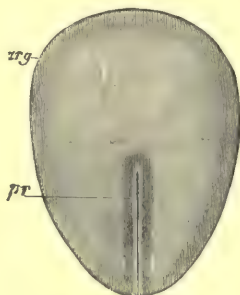


FIG. 95.—EMBRYONIC AREA FROM THE OVUM OF A RABBIT OF EIGHT DAYS. $\frac{2}{1}$ (From Kölliker.)

arg, border of the embryonic area; *pr*, primitive streak with groove.

has met all the requirements of a general nervous system and determining agent, in the work of developmental evolution.

Now comes a momentous period in the history of embryonic advancement, when the foundation, of the future systemic nervous system, is laid in the posterior and half of the neurenteric canal, and when the division of the canal into two takes place, and its anterior division is converted into the alimentary and respiratory systems, of viscera and organs, and, inasmuch, as this great process of structural and functional, differentiation is accompanied,

and followed by the dovetailing, inter-penetrating and blending of the whole of the systemic and sympathetic, nervine and non-nervine, structural elements, respectively, into one organic whole, in which all are correlated and co-ordinated, for systemic ends, and purposes, while structural and functional individuality is maintained, for local ends and purposes.

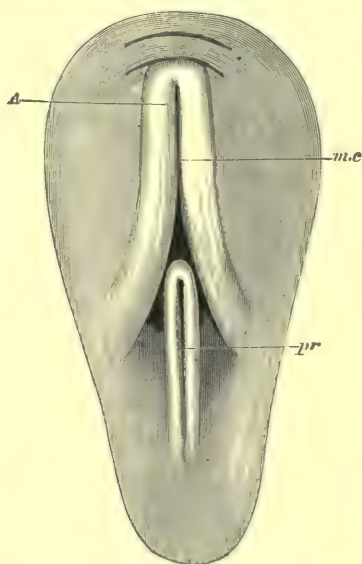


FIG. 96.—SURFACE VIEW OF THE TRANSPARENT AREA OF A BLASTODERM OF 18 HOURS, SOMEWHAT DIAGRAMMATIC. (From Balfour.)

pr, primitive groove, closed in front by the coalescence of the two lateral ridges; *mc*, medullary groove, having on each side the medullary folds or ridges, *A*, which also meet in front to enclose the groove, but diverge behind so as to enclose the primitive streak; in front the fold of the amnion is commencing.

During this momentous period, the systemic nervature inserts itself into the structural area, innervated by the sympathetic nervature, while the sympathetic nervature actually produces and innervates the whole of the textures out of which the systemic nervature is evolved, as well as, the interstitial textures of the muscular, and osseous, systems, with which it is continuous in texture, and function.

The systemic nervous system (Fig. 97), including brain, cord and nerves, is the crowning product of developmental evolution, and, therefore, its every necessity

is most elaborately provided for, anatomically and physiologically, even to the physical extent that it is universally surrounded and interpenetrated by a fluid medium (Figs. 98, 99), in which it floats, free from the exigencies of an ever-changing environment, and sustained, by a series of anatomical structures of a marvellously perfect order, subservient to its every requirement, and

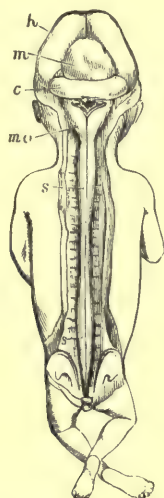


FIG. 97.—BRAIN AND SPINAL CORD EXPOSED FROM BEHIND IN A FÆTUS OF THREE MONTHS. (From Kölliker.)

h, the hemispheres; *m*, the mesencephalic vesicle or corpora quadrigemina, *c*, the cerebellum; below this are the medulla oblongata, *mo*, and fourth ventricle, with remains of the membrana obturatoria. The spinal cord, *s*, extends to the lower end of the sacral canal, and presents the brachial and crural enlargements.

amenable, to some degree, to the control of the will, when it becomes perfectly evolved.

The organs of sense are placed in the most favourable positions to secure information from the external world, and supplied with receptive organs, capable of receiving information from all points, and from all forms of material, and energy, and conveying them, in the most specialised forms, through appropriate neural channels, to the sensorium within, when it, in turn, becomes fully evolved.

At this early period, moreover, are provided the "ways and means," by which the *vis medicatrix nature* is enabled to maintain a hygienic condition of the systemic nervature,

as well as of its sympathetic partner; as an example of that provision, there is established a system of discharging, from within the systemic nervine structures, the results of

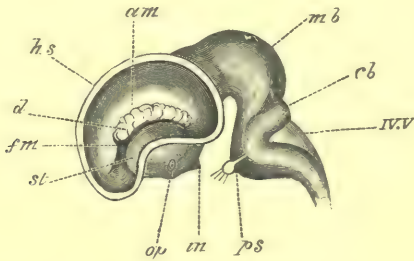


FIG. 98.—LATERAL VIEW OF THE BRAIN OF AN EMBRYO CALF OF 5 CM. (From Balfour, after Mihalkovics.)

The outer wall of the left hemisphere is removed to show the interior of the lateral ventricle; *hs*, cut wall of the hemisphere; *st*, corpus striatum; *am*, hippocampus major; *d*, choroid plexus of ventricle; *fm*, foramen of Monro; *op*, optic tract; *in*, infundibulum; *mb*, mid-brain; *cb*, cerebellum; *iv.v*, roof of fourth ventricle; *ps*, pons Varolii; with fifth nerve and Gasserian ganglion.

structural “tear and wear,” and, so, of maintaining a condition of intra-cerebro-neural health and material sweetness, of the whole nervature.

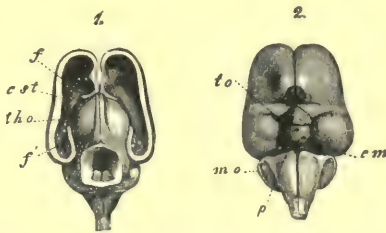


FIG. 99.—BRAIN OF THE HUMAN EMBRYO OF THREE MONTHS. NATURAL SIZE. (From Kölliker.)

In 1 the view is from above, the upper part of the cerebral hemispheres and mesencephalon having been removed. *f*, fore part of the divided wall of the hemisphere; *f'*, hind part of the same which becomes the hippocampus turned in; *cst*, corpus striatum; *tho*, thalamus opticus.

In 2 the lower surface is represented; *to*, tractus opticus; and in front of this the olfactory bulbs and tracts; *cm*, single mass of the corpora mamillaria not yet divided; *p*, pons Varolii. The cerebellum and medulla oblongata, *mo*, are seen behind and to the sides in both figures.

These “ways and means” we have already described at some length, so we here, only recall attention to the double processes of differentiation and union which take place simultaneously at the posterior and anterior extremities, of the neurenteric canal. Thus, at the anterior extremity

while the posterior is undergoing a metamorphic change, by which the lumen of the canal is being occluded by the deposition of connective tissues, previous to cerebro-spinal excretional discharge, through the line of differentiation, and secured by the highly developed coccygeal glandular receptacle and exit vasculature—a mutual approach (see Figs. 30, 32), of the two anterior terminal ends of the neurenteric canal, is taking place; the buccal cavity and the floor of the mid brain extending themselves towards each other until they have become absolutely contiguous, when their respective tissues cohere, and become conjointly encapsulated, whereby is produced, the structure, or organ, known to anatomists as the pituitary gland (see Fig. 32), a structure which is supposed to be functionless, and which from time to time has had various, somewhat fantastic, duties, assigned to it. These assignments of function it is not now necessary to refute, but it is necessary, that we should claim, for this developmental production, a function of the highest order, that any bodily structure can lay claim to, viz. *that of providing an antero-central outlet for the drainage of the great central cerebral organ, the brain.* In claiming for it this most important vital duty, we base our opinion on its essential anatomical structure and histological characteristics, which are those of a true gland, its simultaneous, provision and opening, with that of occlusion, of the posterior-inferior end of the neurenteric canal, the provision of structural developmental materials for the establishment of circulatory facilities between the buccal cavity and the cerebral cavity, at the earliest period necessary for the regulation of intra-cerebral pressure, the facts, that a cartilaginous, and then an osseous, foundation (see Figs. 33, 34, 35, 36), are produced for its support, and independent existence, as one of the first acts of solidification, and ossification of the future skeleton, and the absolute necessity, for the preservation of the hygiene of the intracranial structures, of an outflow mechanism, capable of meeting the requirements of the central cerebral organs, and inter-meningeal spaces, as these requirements, by the process of developmental necessities, come into existence.

During the period of foetal changes and development, great variations are effected in the completeness with

which the systemic and sympathetic nervatures are mutually intermixed and related, so that, when the independent existence, is attained, the systemic nervous system is able to take up the duty of learning how to carry out the work of a voluntarily superintended, and, more or less intellectually directed, organism.

As this process of, foetal and infantile learning, goes on, the growing, and developing, organism, undergoes a process of structural perfecting, by which it is, more and more, prepared to carry out the increasing working necessities of the growing intellect, until a state of material maturity is attained, after which, it may be, that the intellect continues to develop, until its material foundations begin to crumble, and decay.

Meantime, during the periods of youth, adult age, and senile decay, the material organism is able, with more or less success, to meet all the requirements of the predominant partner, by virtue of the possession of the truly wonderful development of evolutionary devices, structural adaptations and functional facilities procured; as, for example, in that developmental device just mentioned, when the systemic nervature was united, by direct glandular and vascular continuity with the alimentary canal, and where, it will be remembered, the buccal cavity, with its lining mucosa, was uplifted into the cranial cavity, and secured, by common encapsulation, to the most dependent central cerebral prolongation, the infundibulum, thereby affording, an outlet from the cranial cavity, by which the work of its drainage could be obtained.

This device is truly one of the most remarkable in the history of the developmental evolution of the human organism, and attracts every day to its manner of working and its functional position in the economy of neural, excretion, alimentation, and digestion, *an unconscious attention*, both lay, and professional, beyond that given to any other part of the economy, for here the mouth, the tongue and the throat, are alike concerned, in the experience of every individual, more or less; and in the light of what has been already advanced, in connection with the subject, it is *bound to become a consciously valuable possession* in the everyday experience of every

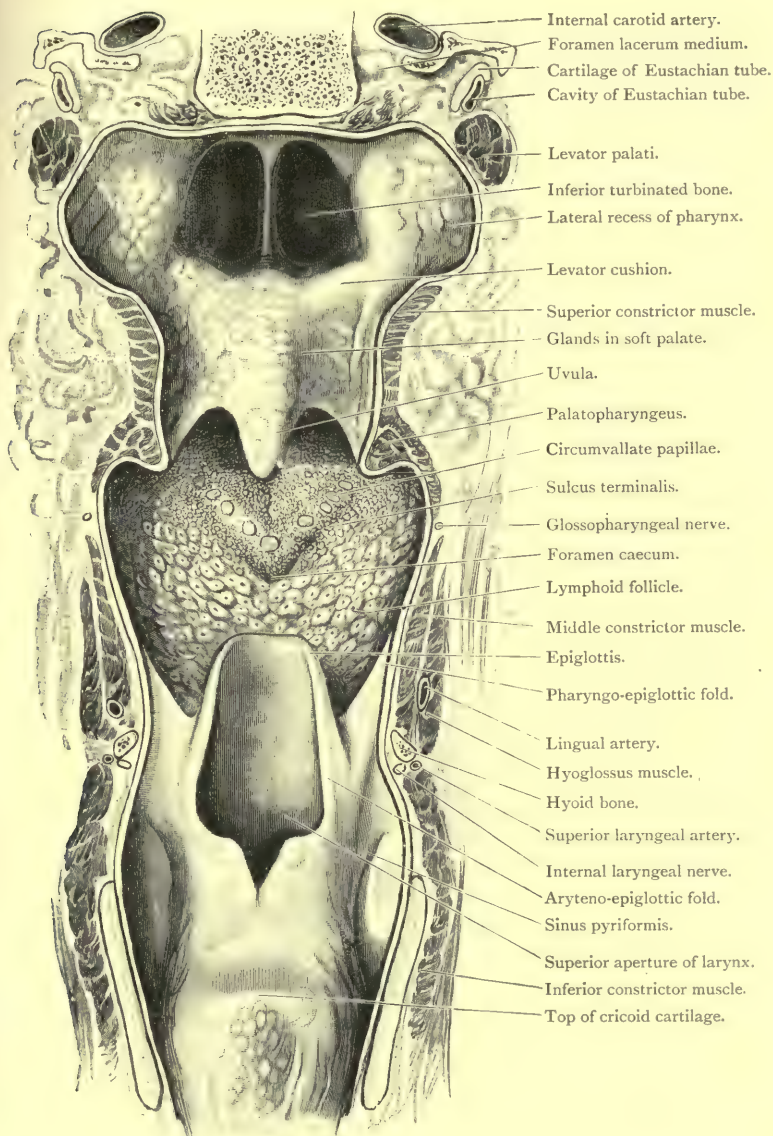


FIG. 100.—THE ANTERIOR WALL OF THE PHARYNX WITH ITS ORIFICES, SEEN FROM BEHIND.

The specimen from which the drawing was made was obtained from a formalin-hardened body by removing the posterior wall of the pharynx while leaving the anterior wall undisturbed. The following points should be noted: the greatest width of the pharynx, above, at the lateral recesses; the posterior nares, with the inferior turbinated bones seen through them; the levator cushion; and the pharyngeal portion of the tongue.

member of the healing art, and the intelligent layman, who takes pains fully to acquaint himself with the nature of the information it conveys. The mucosa of the whole buccal (Fig. 100) cavity, with the structures which it covers, is, more or less, active, in the functional work of cerebral excretion, more or less, modified lines of exit, continuing to maintain that excretional function, first established by the direct union of the buccal and cerebral, cavities, at the antero-central aspect of the nascent cerebrum.

These local structural lines of exit may be likened to those of a sponge, which, on being squeezed, by every act of deglutition, conscious, or unconscious, and every movement of the tongue, empty themselves into the mouth, relieving the outflow vasculature, and, secondarily, assisting in the work of digestion, and alimentation, thus contributing to the double function of secretion, and excretion, and aiding in the economy of the great nutritional activities of the body at the same time.

Such are a few of the steps of the organic developmental evolution of the human organism, and they may suffice to show the absolute continuity of the process, the constant adaptation of means to ends, the survival of the fittest, in texture and organ, and the culmination in attainable perfection, of both structure and function, but with the inexorable final result of material, textural involution, decay and death.

Contemporarily with this process of organic developmental evolution, moreover, a higher, or psycho-dynamic, evolution is being effected, whereby the growth of the, *ego*, inner man, or intellectual being, is secured, in harmony with the various stages of advancement characterising that organic developmental evolution.

The rudiments of psychic being begin to manifest themselves in very early infancy, rapidly increase as the period of lactation advances, continue active during the period of childhood, gather strength during the "acquirement of education" and merge into full intellectual development during the succeeding years, increasing, as "knowledge of the world" becomes added to the mental furniture.

Along with these mental evolutionary changes is being added, as the last and highest developmental change, in the whole category of human evolutionary events, viz. the production, growth and development of moral character and attributes, which being the last product of human developmental evolution, and the final stage of dynamic change, in the innermost nature of man, becomes the concluding and essential, event in that long series constituting the whole "life of man," comprising, material, intellectual, and moral.

EXTRACT XXII.

ON THE NOTOCHORD, AS A SKELETAL EVOLUTIONARY FACTOR.

WHAT does the term notochord signify? No answer to that question has yet been vouchsafed to the most "anxious inquirer," and the subject has to a great extent been "shelved," or "hung up," waiting the advent of a suitable time, and circumstances propitious, for the consideration of questions considered devoid of all possible practical advantage, but which may have an element of possible scientific interest, sufficient to excite a "passing notice." In the latter aspect of the subject, we feel called upon to take it up, in order, if possible, to throw some light, if it be only that of curiosity, upon it.

To begin with, the history of its discovery is, so far as we have been able to make out, comparatively recent and has consisted of its topographical delimitation and the recognition of its anatomical details, all of which is highly informative to the student of embryonic structure and valuable, as a "find," to the collectors of anatomical archæology and evolutionary survivals, but it does not satisfy even *mere* curiosity, we therefore, feel impelled to soliloquise for a little on its probable meaning, after, for some time, regarding it as intently, as we have been able, from the various aspects reachable from our individual points of view. In attempting an explanation of its nature, we would observe that its embryonic advent seems, to us, to *anticipate* the process of skeletal building, and to *synchronise* with the erection of the scaffolding, so to speak, by the formative factors, in the great work of

growth and development, or evolution, of the human organism; it is a structure, therefore, of an ephemeral order, which, when its developmental services are no longer required, is relegated to that class of "survivals," which now has assumed, a *more or less*, "recognised

FIG. 101.

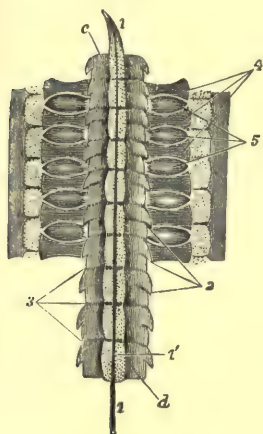


FIG. 102.

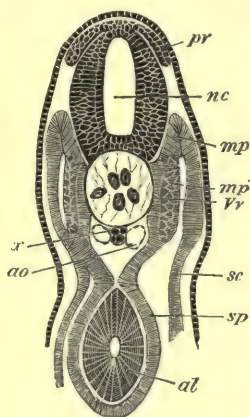


FIG. 101.—CERVICAL PART OF THE PRIMITIVE VERTEBRAL COLUMN AND ADJACENT PARTS OF AN EMBRYO CHICK OF THE SIXTH DAY, SHOWING THE DIVISION OF THE VERTEBRAL SEGMENTS. (From Kölliker after Remak.)

1. 1, chorda dorsalis in its sheath, pointed at its upper end; 2, points by three lines to the original intervals of the primitive vertebræ; 3, in a similar manner indicates the places of new division into permanent bodies of vertebræ; c, indicates the body of the first cervical vertebra; in this and the next the primitive division has nearly disappeared, as also in the two lowest represented. viz. d, and the one above; in those intermediate the line of division is shown; 4, points in three places to the vertebral arches; and 5, similarly to three commencing ganglia of the spinal nerves: the dotted segments outside these parts are the muscular plates.

FIG. 102.—TRANSVERSE SECTION OF EARLY EMBRYO OF PRISTIURUS (ELASMOBRANCHS). (From Balfour.)

nc, neural canal; pr, posterior root of spinal nerve; x, subnotochordal rod; ao, aorta; sc, parietal mesoblast; sp, visceral mesoblast; mp, muscle-plate; mp', portion of muscle-plate converted into muscle; Vv, portion of the vertebral plate which will give rise to the vertebral bodies; al, alimentary canal.

position," in our scientific structural classifications and nomenclature.

From its position, as to time of appearance as a fully-formed anatomical element (Figs. 101, 102, 103), amid the teeming array of rapidly evolving structures, and functions, we would "naturally" suppose that it must have a very important duty, or bearing, as well as, from its central, and evidently determining, localisation, on the

process of, embryonic, as well as, foetal, development. Thus, it appears, when the process of differentiation of the neurenteric canal becomes effected, by posterior division, and anterior union, or by the development of the coccygeo-anal, and pituitary, metamorphic, separating, and uniting, mechanisms, or organisms; it culminates during the formation of the vertebral column (Figs. 103, 104); and declines in prominence, as that part of the skeleton reaches the stage of advanced, if not completed, ossification, in its formation; and persists, until the vertebral

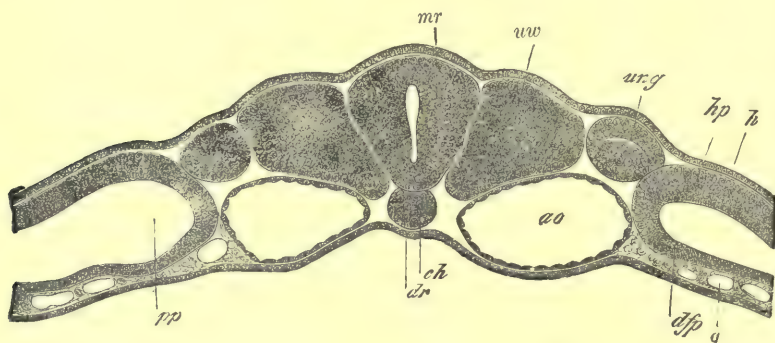


FIG. 103.—TRANSVERSE SECTION OF AN EMBRYO RABBIT OF 9 DAYS AND 2 HOURS IN THE MIDDLE DORSAL REGION. 188 (From Kolliker.)

mr, medullary tube; *uw*, protovertebral mass; *h*, epiblast; *hp*, parietal mesoblast; *dhp*, visceral division of the mesoblast; *pp*, pleuro-peritoneal cavity between them; *ur.g*, primitive segmental duct; *g*, vessels in the visceral mesoblast; *ch*, notochord; *dr*, intestinal groove of the hypoblast.

centres have progressed to the full extent of their peripheral boundaries, and have assumed their proper position in the structure of the fully-developed spinal column, when it begins to decline in prominence of anatomical features, and shrinks into the condition of a *survival of itself*. What, we ask ourselves, does all this suggest? It suggests that the notochord, at this period of embryonic development, is performing a most important function in the economy of growth and evolution of the embryonic formation skeletal structures, and from its intimate relationship, at its anterior extremity, with the process of differentiation, or rather union, of the already divided extremities of the neurenteric canal, it receives from that canal and its proper, neuro-mural, or structural, elements,

earthy or ossific material to distribute to distant developing chordal textures, whereby they can undergo the common process of growth, then so active everywhere throughout the embryonic organism; we, therefore, would regard it, as a vascular mechanism, or vehicle, whose function—a temporary one—ceases with the arrival of the more advanced foetal condition, when the necessity for its

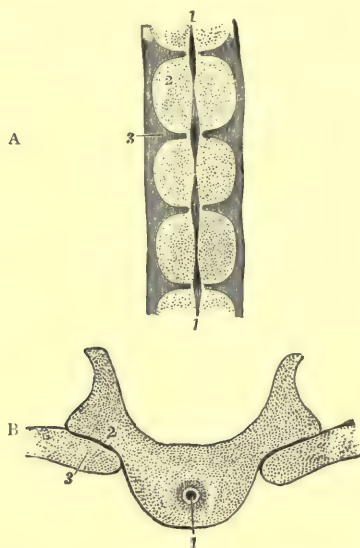


FIG. 104.—SECTIONS OF THE VERTEBRAL COLUMN OF A HUMAN FŒTUS OF EIGHT WEEKS. (From Kölliker.)

- A, transverse longitudinal section of several vertebræ. 1, 1, chorda dorsalis, its remains thicker opposite the intervertebral discs; 2, is placed on one of the bodies of the permanent vertebræ; 3, on one of the intervertebral discs.
 B, transverse horizontal section through a part of one dorsal vertebra. 1, remains of the chorda dorsalis in the middle of the body; 2, arch of the vertebra; 3, head of a rib.

existence no longer continues; and this latter stage would seem to be reached when the ossification of the various units of the vertebral column has been effected to that extent, which yields a stable, protection and support to the developing brain and spinal cord, and which then allows its future nutritional economy to be developed, on the ordinary lines of growth, to the stage, of *self-supporting efficiency* and organic independence.

If this be so, and we regard it as developmentally reasonable, and suitable, in the circumstances, we should

suppose that the materials entrusted to the notochord for nutritive disposal, consist of, amongst others, the inorganic, or more mineral, elements of bone structure, which it deposits, for metabolic purposes, in the sympathetically constructed fibro-cellular foundation elements, or centres of ossification, of the future individual vertebræ, as well as, for the growth, and development, of all the continuous textural extensions and terminal distributions associated therewith, or proceeding therefrom.

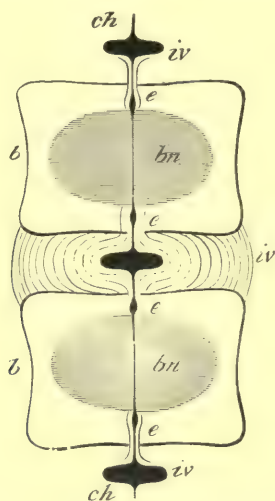


FIG. 105.—DIAGRAM TO SHOW THE POSITION OF THE ENLARGEMENTS OF THE NOTOCHORD IN PASSING THROUGH THE VERTEBRAL COLUMN. Half the natural size. (After Kölliker, A. T.)

ch, notochord; *b*, bodies of two vertebræ; *iv*, intervertebral plate with the wide enlargement of the notochord; *bn*, ossific nucleus of the bodies of the vertebræ; *e*, slight dilatations of the notochord opposite the epiphysal plates.

The reason of the structure in question lapsing at this stage of organic evolution is, that it ceases to occupy the position of an active, vehicular, or vascular, structure, and, like such unemployed ducts as the thyro-glossal, fails to attract further notice. During the period of its functional activity, or before the nutrition of bone, generally, is effected by periosteal agency, we have the materials, for the growth of bone, carried to the bodies of the future vertebræ by notochordal means, and their *ossification in advance* secured, in preparation for the laying

down of the fundamental structures of the future systemic nervous system.

In this earliest skeletal development, we see in full activity, the membranous, and cartilaginous, methods, of ossification (Fig. 105), in order to overtake the much required developmental work of providing, at the earliest period, both external and internal means, of organic support and protection, before the usual factors for permanent osseous structures have been laid down, or come into existence, and it is most remarkable and suggestive to find that these phenomena are displayed in connection with the nascent systemic nerve centres, where the basi-sphenoid cartilages are developing, round,

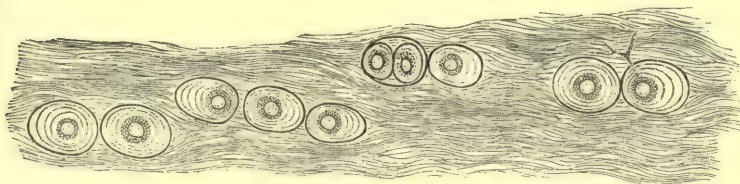


FIG. 106.—WHITE FIBRO-CARTILAGE FROM AN INTERVERTEBRAL DISK (HUMAN). Highly magnified. (E. A. S.)

The concentric lines around the cells indicate the limits of deposit of successive capsules. One of the cells has a forked process which extends beyond the hyaline area surrounding the cell, amongst the fibres of the general matrix.

and under, the central brain structures, and the vertebral bodies, under, and in front of, the developing spinal cord.

The notochord may, thus, be compared to an *internal periosteum*, and, therefore, we may correctly call it the *end-osteum* of the vertebral column, as it traverses its united textural units, carrying their earthy nutritive elements, as long as it is necessary for it to do so, and disappearing, into anatomical obscurity, on the establishment of other, and permanent, means, of carrying on, its hitherto essential, vehicular work. Thus employed, it bridges over a period in the process of skeletal growth, when the periosteal structures of the skeleton, generally, are in course of evolution, and, of course, before the period at which protection and support are absolutely necessary for securing the growth, and evolution, of the future systemic nerve organs, the brain, and spinal cord.

Its position, in relation to the developing vertebræ, assumes a central course, which it continues to maintain, after it has ceased to perform an active functional work, and is found surviving even in adult life ; it is, therefore, one of those structural *survivals*, about which it is not too much to say, that, it is conceivable, it may have to do with functional *revivals*, physiological, or pathological, such as we have claimed for the thyroglossal duct, in relation to the etiology of some cases of goitre.

Moreover, we would draw attention to the resemblance of the function, we have assigned to this embryonic structure, to that usually assigned to the periosteum of the bones, constituting the other parts of the skeleton (*i.e.* excepting the bones, to which the notochord conveys ossific matter during its active existence), in the physiological process involved in the formation of *callus*, between, and around, the ends of fractured bones, during their course of "knitting," and restoration to complete, if not exact, continuity of texture. Here, it would seem to us, that a large portion of the callus, if not all, is of nervine origin, in which respect it exactly resembles the ossifying material, deposited from the notochord amid the centres of ossification of the individual vertebræ, and that it is deposited from the ruptured periosteal, and fractured bone, structures, and licked into organic form by the inter-penetrating and omnipresent, sympathetic nervature.

From this it would appear, that the systemic nervature is responsible for a large proportion of the growth, and nutrition, of all the structures subservient to its voluntary control, and that it, therefore, seems *no longer strange* to meet with cartilaginous, or osseous, deposits, not only in immediate relationship to the proper skeleton, but throughout the whole organism, wherever the systemic nerve structures are distributed.

Like neuroma, which is an accumulation, in the neurilemmar sheaths, of the white substance of Schwann, disconnected deposits, or growths, of cartilage, or bone, found up and down the body, are arrested osseous, and, more or less, organised, materials, due

to stasis of systemic nerve circulation of these materials, from physiological, or pathological, circumstances, and factors.

The notochord, thus, becomes the prime agent in securing the embryonic safety of the nascent, and developing, elements, of the systemic nervous system, in respect, especially, of the great central organs of brain and cord, and in providing the central support, for the subsequent development of the thoracic, and pelvic, arches, and their attached limb continuations, certainly, a functional *raison d'être* of the utmost importance to the embryonic organism, and of no less prospective importance, in the future development of the growing, and maturing organism.

All which is, no doubt, highly speculative, but absolutely deducible from the, embryological, histological and physiological, data, of which we have become possessed, and which we have utilised to our own satisfaction, in elucidating themes, and formulating opinions, in other, but kindred, regions, lying immediately outside of absolutely proved, and orthodox, doctrine, and teaching; we, therefore, make no apology for obtruding such views, on the attention of those capable of appraising them at their proper value.

As a vascular, or vehicular, structure, it is not capable of circulating its contents in the ordinary sense of the word, inasmuch, as it has no proper outfall mechanism, so far as yet known, and no return vasculature, to re-deliver its residual and acquired, contents, to its original source of supply; it may, therefore, be regarded as a canal, into which, percolates, or finds its way, the ossific material destined for the future vertebral bodies, and to the evolved rudiments of which it communicates, by osmosis, what it has to yield, at regular stages along its lumen, until it has emptied itself and become, so to speak, dried up, or, in reality, *evacuated*.

The notochord is one of the earliest structural dispositions of the blastodermic fundamental layers, synchronising in time of development, and running parallel in position, with the neural canal, which it apparently finally joins at, or in, the hypophysis, where

the buccal cavity is brought into relationship with the cerebral vesicles.

When this triple junction of structures and included intra-spaces, becomes fully established, the shrinkage, and involution of the notochord, begins, which seems to mean, that the material, hitherto deflected along the lumen of the notochord, becomes finally deflected, through the anterior lobe of the now encapsuled pituitary gland, into the buccal cavity, the direction which it is destined permanently to take, as a means of keeping open, a communication between the cavities of the brain and alimentary canal, and, so of securing the drainage of the skull, and its nervine contents, in perpetuity.

Moreover, when such a disease as acromegaly ensues, and when we look about for a reasonable etiology of such an enigmatic condition, we are persuaded, we shall find it in a *perversion*, of the "state of things," brought about by the above-mentioned triple circulatory embryonic arrangement; thus, the material circulated by the notochord, and distributed by it to the ossifying vertebræ, contains ossific, and developmental, elements, which, on its functional exhaustion, are turned into the pituitary organism for disposal, and should find their way into the pharynx. This material, on the advent of acromegaly, is dammed back by, it may be, the disorganised pituitary excretory structures, and has to find its way, along the lines of least resistance, leading from the site of excretory arrest, and, subsequently, and consequently, into the terminal extensions of both the efferent, and afferent systemic nervatures, where it produces the characteristic, osseous and cutaneous, enlargements, the pituitary body being the *fons et origo* of the whole sequence of morbid events, by an unbroken continuity of occurrences. Moreover, the reputed tendency, for bones which have been simultaneously fractured, and had their attached muscles deprived of systemic innervation, to remain ununited, is explained, by the incidence of, what we would designate, the *law of nutritive continuity* between, nerve, muscle, periosteum, and bone, having been violated in its nervine links, or compartments.

In comparison with the notochord, both in structure,

and function, although a matter of altogether vegetable bearing, we cannot forbear calling attention to the pith of plants, a ligneous element, which seems to perform in the process of plant life and growth, a very similar function to that of the notochord in animal embryonic life, conveying to the distal buds from the earth, we think, the inorganic, or earthy, salts, and other materials, for the solidification of ligneous tissue, while the more aqueous, and organic are conveyed up the exterior in the sap proper. Of course the pith of plants is a permanent, and not an ephemeral structure, and continues *annually*, or *perennially*, to perform its vital functions of circulation and lignification.

We seem here, in embryonic life, to be face to face with problems, involving the conjoint action, of both the sympathetic, and systemic, nervatures, not only on their material aspects, but on their dynamic; so that we have the play, in the accomplishment of the phenomena referred to, of four factors, two material, and two dynamic, viz. the sympathetic, material, and dynamic, neuro-circulatory, each of which is called upon to act individually, and communally, for the accomplishment of common organic objects. Necessarily, therefore, the partnership working out of the problems in question entails very complicated methods, of formative, and reparative, procedure, but when the physiological compact is capable of straightforward accomplishment, the various factors, mutually, and spontaneously, assist each other, so that finally, what had seemed an impossible work, is accomplished with the utmost, ease and precision.

Thus, the material lines having been determined upon, and laid down, the dynamic factors lick into shape the mutual material contributions of the two systems, and evolve organic order, out of what may have appeared chaos, as when—in the case of bone fracture, callus has been contributed from all sources in the scene of the traumatic area—it becomes necessary, for the accomplishment of the one object, of attaining the condition of the *status quo ante*, for both systems to put forth their accurately guided dynamic efforts, for the common purpose of securing a physiological, and avoiding a pathological result.

Likewise, in the development of the nascent vertebral column, the foundation plan, and materials, have been determined upon, and laid down, by the evolving sympathetic nervature, antecedent to the appearance of the nascent systemic nervature, which, when it has attained the requisite degree of development, diverts the necessary materio-dynamic elements into the notochordal texture, to accomplish the ossification of the bodies of the future vertebræ, and to ensure a stable foundation being constructed for the fully developed systemic nervature. On both these procedures follows, the removal, or involution, of the no longer required, reparative, or constructive, materials, as residual elements, as should always follow on the lapse of function, in order to leave no nidus, or nucleus, on which the agencies of disease can seize, and convert, to pathogenic uses, therefore, absorption ensues, in the one, and shrinkage, in the other, until, physiologically, their presence is known no more.

Along with the physiological working out of these problems, unfortunately, pathological presences may "turn up" on the scene, such as rheumatism *et hoc genus omne*, when, what has been a process of "plain sailing," becomes one of "tacking, and turning," until the *vis medicatrix nature* succeeds in thwarting the intentions of the enemy, and restoring order.

In regard to the very early appearance, in the embryonic structural economy, of the notochord, as a definitely organised element, and its subsequent all but complete disappearance, we are persuaded, more and more, that it subserves one of the most important, formative, or developmental, purposes; more especially, as we have said, in connection with the process of ossification, and the formation of that part of the skeleton, which is destined to, continue, and protect the central structures of the systemic nervous system; thus, up to the time of its appearance, no indication of the skeletal tissue has manifested itself, and nothing, but the most rudimentary indication, of neuro-muscular development, which, according to our views of the nutritional functions of the notochord, precludes the possibility of ossification taking place from it, at that formative juncture; what more

essential then than that a temporary developmental procedure, or expedient, should take place, and a temporary organism be provided, to meet the temporary organic occasion? And this is, neither more nor less, than what takes place under the circumstances, by the evolution of the structure known as the notochord. In this temporary developmental procedure, we, therefore, claim, that a great materio-dynamic problem has been carried out, by which formative difficulties, otherwise insurmountable, have been overcome, and the first step forward been taken, in the production of a vertebrate and skeletally possessed, animal.

In the provision made for the purpose, we see a temporary ductiform structure laid down from the anterior end of the neural canal, from which we conclude is drained off, from the contents of that canal, the earthy salts, necessary for effecting the ossification of the future vertebral bodies, the percolation of them into the fibro-cellular matrix of these bodies, and the subsequent cartilaginous consolidation, and ossification, of them, followed by involution, and very slight survival of the temporary structure.

After the development of the neuro-musculature, the process of ossification, and skeletal nutrition, are effected through the joint agency, of nerve, muscle, and intermediate, or uniting musculo-skeletal, textures, tendonous, and periosteal.

Lime, among other earthy ingredients of living protoplasm, becomes, thus, separated from its physiological companionship with the other plasmic elements, and is transmitted, by means of notochordal circulation, to effect a new mode of union with these elements, by being, as it were, *strown* amongst them, to give them the property of solidity, and the consequent power of resistance, and adaptability to the structural necessities of the growing organism, in its evolution of an articulate skeleton—lime, thus, once more asserting itself, as one of the most essential elements in nature, as well as one of the most widely distributed.

It is, thus, most remarkable, that earthy matter is separated from the sympathetically innervated organic

elements, by the nascent systemic-nervature, and reintroduced into the sympathetically innervated vertebral bodies, with the result, that an organic precipitation, as it were, takes place in the process of ossification, illustrating, once more, the continuous existence of circulation within circulation.

EXTRACT XXIII.

ON OSSIFICATION, AND THE SKELETON.

OSSIFICATION, as an embryonic and early foetal, histological process, begins, after the differentiation of the neurenteric canal, and the early evolution of the structures, springing from the areas, respectively innervated by the sympathetic and systemic nervous systems, and progresses, in the first instances, mainly by cartilaginous modes of solidification, of certain definite points, or small areas, of, the then, entirely soft tissues, such as, the bases of the future units of the vertebral column, and the basi-sphenoid, para-chordal and trabecular, cartilages.

This earliest example of the process synchronises with the appearance, and functional activity of the notochord, and seems due to the distribution of earthy material—lime salts especially—by that, then, prominent embryonic structure, to the fibro-cellular matrix of the future vertebral bodies, and speno-chordal basal tissues—the physical union of the two skeletal evolutionary elements, protoplasmic, and earthy, their structural solidification, as cartilage, and their subsequent conversion into bone, by absolute ossification, following as the terminal result.

When this earliest skeletal provision has become effected to the extent, that the future systemic neuro-musculature, can obtain sufficient support, solid points of attachment, and protection, to develop itself throughout the areas of sympathetic innervation, the process of ossification is repeated, at points corresponding with what are called “centres of ossification,” throughout the whole skeletal areas of the, calvarium, body and limbs of the developing

fœtus, by neuro-muscular plasma, provided from the central, or systemic, nervous system, through the axonal processes of its various neurons, which seem to repeat, on

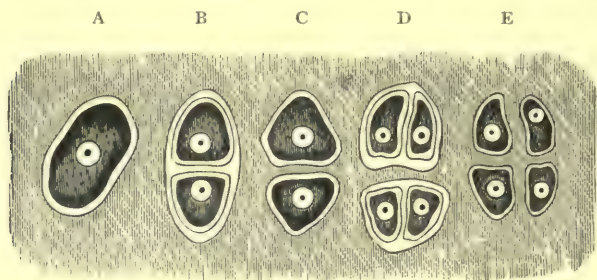


FIG. 107.—IDEAL PLAN OF THE MULTIPLICATION OF CELLS OF CARTILAGE. (Sharpey.)

A, cell in its capsule; B, divided into two, each with a capsule; C, primary capsule disappeared, secondary capsules coherent with matrix; D, tertiary division; E, secondary capsules disappeared, tertiary coherent with matrix.

the same lines, the ossificatory proceedings of the early notochord, each neuron carrying, or sending, to its appropriate osseous centre of attachment and distribution, the

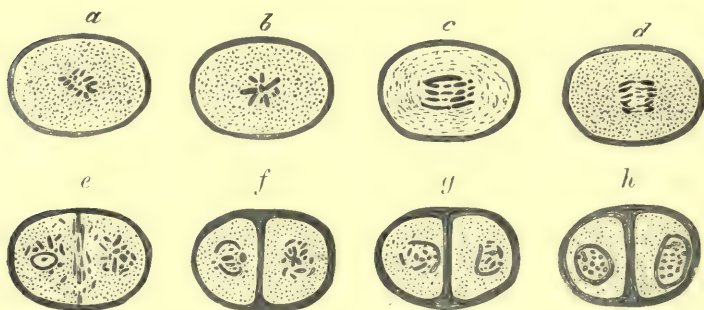


FIG. 108.—DIVISION OF A CARTILAGE CELL. (Schleicher.)

a-h, stages of division of a cell, as seen in the living cartilage of the salamander (the connection of the nucleoplasmic filaments could not be made out in the fresh condition). a, b, stellate phase; c, equatorial phase; d, commencing separation of the nucleoplasmic filaments; the further stages of separation are not represented; e, filaments fully separated into two groups, and a septum beginning to be formed between them; f, septum completed, seen to be double and continuous with capsules of daughter cells; g, h, further stages in the formation of the daughter nuclei.

requisite plasmic and earthy material, for the solidification, and ossification, of the point, or area, to which it is locally conveyed. Ossification is said to manifest itself in two ways, or manners, viz. by (Figs. 107, 108) cartilage,

and membrane (Figs. 109, 110), but, to us it seems to manifest itself in two degrees, viz. cartilaginous (see Fig. 107), and fully osseous (see Fig. 110), and that sometimes it remains at the cartilaginous stage, as in the cartilages of the ribs, the joints and air passages, where the property of greater elasticity is retained, with the conferred skeletal stiffening. Moreover, as age advances, a process of

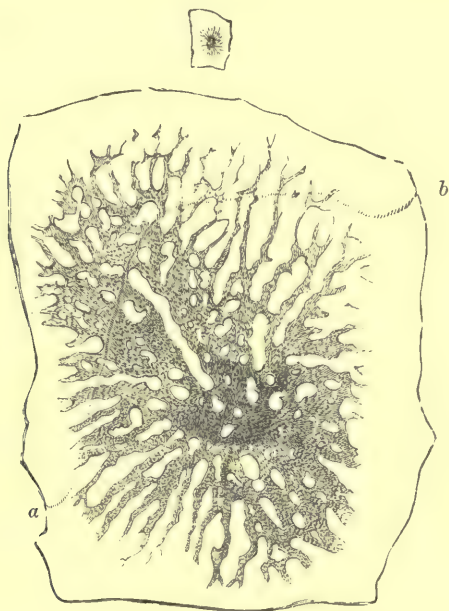


FIG. 109.—PARIETAL BONE OF AN EMBRYO SHEEP. Size of the embryo, $2\frac{1}{2}$ inches. (Sharpey.)

The small upper figure represents the bone of the natural size, the larger figure is magnified about 12 diameters. The curved line *a*, *b*, marks the height to which the subjacent cartilaginous lamella extended. A few insulated particles of bone are seen near the circumference, an appearance which is quite common at this stage.

stiffening is undergone by these cartilaginous structures, and frequently there are laid down, nodules, or more developed structures, in various localities by preference, which undergo a series of structural changes, due to the deposition in their matrix of earthy material, which ultimately may lead to the development of a supplementary skeleton, or detached osseous structures, the growth of which is usually manifested along what we might call, the

natural evolutionary lines, and by the natural evolutionary materio-dynamic machineries.

The occurrence of these ossificatory changes appears to depend on the deposition, amid the neuro-plasmic material, at some exposed, or degenerate, part, of its circulatory surroundings, of the saline ingredients of the accompanying cerebro-spinal lymph, which, then, and there, initiate, and continue, the resolution of the combined lympho-plasmic elements, into cartilaginous, or

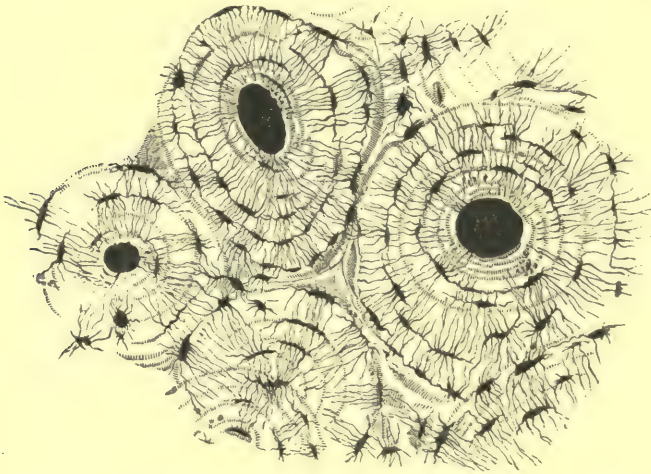


FIG. 110.—TRANSVERSE SECTION OF COMPACT TISSUE (OF HUMERUS). Magnified about 150 diameters. (Sharpey.)

Three of the Haversian canals are seen, with their concentric rings; also the lacunæ, with the canaliculi extending from them across the direction of the lamellæ. The Haversian apertures had become filled with débris in grinding down the section, and therefore appear black in the figure, which represents the object as viewed with transmitted light.

osseous, tissue, in accordance with the character of the structural environments, and the strength and continuance of the ossific evolutionary process.

The nervous system, but more especially the systemic motor nervature, seems to possess, within itself, the materials, saline, or earthy, and plasmic, for the spontaneous development, when the formative conditions are favourable, of cartilage, and bone, and, so, an explanation is afforded of the scattered attempts at ossification, so plentifully apparent in certain individuals, at certain times,

and the necessity for the presence, of the systemic motor nervature in fractures of the skeleton.

The notochord, therefore, becomes obsolete, when the ossification of the vertebral column is complete, and then undergoes a process of involution, ending in its almost entire disappearance. Nevertheless, it is just possible, that some obscure processes of osseous affections of the vertebrae, may have some relationship, to this very slight survival of its lumen, amid tissues functionally active.

When ossification of the general skeleton, apart from the vertebral column, and the basi-sphenoid begins, we are warranted in tracing its lines, along the continuous histological developments comprising the neurons proper,

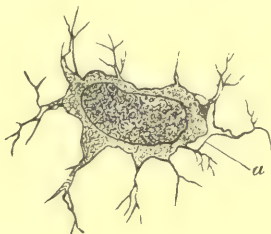


FIG. III.—A BONE-CELL ISOLATED AND HIGHLY MAGNIFIED.
(After Joseph.)

a, proper wall of the lacuna, shown at a part where the corpuscle has shrunk away from it.

their axonal processes, the muscle plates and systemic musculature, and the meso- and hypo-dermal textures, in which these terminate, to which they become attached, as the process of ossification proceeds, and with which they become continuous, by tendonous insertion and periosteal continuity with the skeletal matrix. Thus, the whole structures innervated by the systemic nervous system, ultimately become blended, and merged, into one systemic whole, by complete histological continuity, nutritional oneness, and functional inter-dependence, of all its parts, neural, muscular and osseous, to the end, that the systemic nervous system, is, or becomes, one and indivisible, in all its elements, with the great sympathetically innervated, surrounding, inter-penetrating, and supporting, mass, of organic structures, and organs, the two systems,

thereby, being enabled to act individually, or conjointly, according to the necessities, of one, or both, by absolutely adjusted means, material and dynamic.

Ossification, viewed thus, becomes the concluding link in the chain of evolutionary processes, involved in the growth of the human organism, from its original unicellular protoplasmic elements, to its voluntary motile condition—being the culminating skeletal “groundwork,” on which is erected, the greatest organic superstructure yet produced, in the meantime overshadowing, and dwarfing, all others, however perfectly they may be adapted, to their environment, and to carry out the peculiar work of their individual and communal, destiny.

With an articulate and movable framework, a motive machinery to bind together, and give it power of movement, a dynamic agency to supply the energy, and a regulative and administrative, consciousness, to guide its conduct, the human organism, or machine, is capable of performing work, of a higher character, than has been attainable by the highest types of lower organisms, and, apparently, a much higher still, than has yet been accomplished by the race, at, even, its most advanced periods of civilisation.

EXTRACT XXIV.

ON LIGNIFICATION IN PLANTS AS COMPARED WITH OSSIFICATION IN THE HUMAN ORGANISM.

LIGNIFICATION, or the consolidation of vegetable tissue, seems to have something in common with, ossification, or the consolidation of animal tissue. Thus, as ossification consists primarily of the invasion of certain structural areas of the nascent organism by earthy salts, the union of these with the structural elements of those areas, the hardening organisation, and ultimate consolidation, of them, on definite skeletal lines, and, so, ultimately, the conferring on the soft structures of a power, to attach themselves to the resistant skeleton, and become, through it, an articulate and moving, organism : so is lignification a hardening organisation and ultimate consolidation of vegetable protoplasm, by its union with earthy matter, in definite fibro-cellular lines, along the stem, branches and leaves, of the plant or tree. In the latter process we see pretty much the same method of the union, or consolidation, of the protoplasm, and earthy elements, in the tissues of the plant, as we witness in the bodies of the vertebræ, through the instrumentality of the notochord—the “pith,” with the medullary rays, acting as the vehicle of transference, from the soil, to the protoplasmic cambium of the plant of the earthy elements, by which the ligneous tissue becomes fully evolved, as a permanent structure.

This necessitates two circulations, the one, passing up the stem, inside its bark, the elements of vegetable protoplasm, while the other transmits, by way of the pith

channels, the medullary rays, and it may be the permanent ligneous structure, the earthy salts held in solution, or suspension, by the indispensable element of water. On the passage of these two fluids through, the cambium, the branch terminals and leaves, they become intermixed, when the phenomena of lignification begin, and result, in temporary, or permanent, additions, to the structure of the plant, in the form of leaves, and increases in the length, and girth, of the plant.

Towards the accomplishment of the process, the provision of pith channels and medullary rays, to a greater, or lesser, extent, is universal, throughout the whole range of, stem, and branches, while the whole external, or peripheral, aspect of the plant, is the scene of one continuous circulation, of *sap proper*, which, meeting with earthy material, through the outer layer of the permanent ligneous tissue, is the means of laying down, another, and new, layer, and, so, of adding, year after year, to the lateral extension of the plant, or tree, and, also, on the admixture at the extremities of the branches, a more, or less, large addition is made to their permanent length, while a very large amount of highly developed, functional, material, is *shed*, in the form of leaves.

EXTRACT XXV. A.

ON THE EMBRYONIC DIFFERENTIATION, OR DIVISION
AND REUNION, OF THE NEURENTERIC CANAL,
WITH SOME ACCOUNT OF THE ALIMENTARY
CANAL AND THE PROCESS OF DIGESTION.

THE neurenteric canal is one of the earliest embryonic arrangements of the organic elements of the blastoderm, and is the outcome of the initial differentiation and structural arrangements of its several parts, the continuation of which is ultimately to culminate, by the organisation of the total of these primary organic elements, in the fully developed body. The organisation of the embryo, at the stage of development represented by the V-shaped neurenteric canal, is necessarily most rudimentary, but still complete enough to meet all the vital requirements of the embryonic body, and to form the developmental basis, on which is to be constructed, the future alimentary, and neural, systems, and the organs of the succeeding nascent organism with their constantly increasing facilities for inter-action and co-operation, in the performance of the complex functional work of the fully developed body.

The division of the neurenteric tube into two—neural, and enteric,—represents a great advance in embryonic development, indicates the first step in the evolution of a systemic nervous system, the dividing point, or line, between sympathetically, and systemically, innervated, creatures, and constitutes an entirely new departure from the sequence of what, may be called, vegetative-life evolutionary phenomena.

The actual differentiation, and division, of the canal, posteriorly, is accompanied by union at its anterior ends in the pituitary body (see Figs. 30, 32), a provision of the most important order in the future evolutionary events impending, in that long series constituting the life-history of the human form, in its passage from the embryonic, to the adult, condition.

The union of the anterior extremities of the neurenteric canal, here effected by the junction of the neural and buccal cavities, produces, or affords, an anterior means of exit, to the fluid contents of the neural half of the canal, when free disposal, or circulation, along the posterior aspect is hindered, by the division and differentiation, there, and there is no longer available, an untrammelled, or unrestricted, condition, of patency—that being reduced to the proportion of providing an exit for the coccygeal residuum of the cerebro-spinal fluid. Division and differentiation, of the two canals, having been fully effected, and a start made in the development of their future separate lumens, each becomes provided with a structural machinery, capable of enabling it to perform the functionary work, of an alimentary organ, and of a systemic nervous system, respectively.

It seems, that during, and after, the completion of the process of differentiation of the neurenteric canal, the great functional work, of the entire body is being apportioned to the two nervous systems, as they, and their related textures, and organs, become evolved, and take their place in the great organic commonwealth of the completed and communal, organism. Thus, the vegetative, or organic, and lower physiological, work, is delegated to the sympathetic nervous system, while the voluntary, psychological, and higher, nervine, work, is delegated to the systemic nervous system, a mixed, or debatable, work, being performed by, one, or the other, or both, in conjunction. It, moreover, seems from physiological, and chemical, observation, warrantable to assume, that the dual, or duplex, dynamic balance, hereby necessitated, is maintained, by mutual exchange, and transference, as well as limited and mutually secured production of energy.

In this way is obtained and maintained a physiologically even employment of the dual organisms, and energies, a graduated activity of all parts of the organism, and a mean, or healthy, biological result, in other words a *mens sana in corpore sano*—the desideratum of desiderata.

The anterior limb, of the neurenteric **V**, becomes subservient to the purposes of the sympathetic nervous system, the two limbs being united, and held together, in their common work, by the inter-agency of a common blood circulation.

In the following remarks on this subject, we shall deal mostly with the enteric division of the canal. During embryonic, and intra-uterine, existence, the range of functional activity of the enteric canal, is necessarily restricted to that, involved in its comparatively passive condition, of preparation for the coming lactation duty, of digesting the carefully elaborated, mammary secretion, and, therefore, at birth, its contents are composed of only the exfoliated residuum of organic waste, enteric, and neural. The enteric canal, during this period, undergoes a gradual evolution from a comparatively straight and plain tube, into a multi-duplicated canal, the walls of which are interpenetrated and surrounded, by glandular developments, and elaborate secreting organs, to fit it for the performance of the most complicated, and vital work, of digestion and alimentation.

The enteric canal, anatomically, is divided, roughly speaking, into mouth, œsophagus (Fig. 112), stomach, and small, and large bowel (Fig. 113), each division being structurally somewhat different, and functionally somewhat distinct, from the other, in accordance with the physiological character of its specific contribution to the common work. It is needless to say that every portion of the canal, and so far as yet discovered, every accessory structure, and organ, appertaining to it, is most perfectly adapted for the performance of its individual office, and unitedly, for the complete accomplishment of the great functional work of preparing the raw alimentary materials of our everyday diet, to meet the nutritive requirements of our everyday life and work. Thus, the mouth, with its masticatory, and insalivating, machinery, performs on

the materials supplied to it by the selective instincts, and prehensile organs of the individual, the initial work of preparation, for gastric digestion and absorption,—besides the procedure of mastication and insalivation, however, we feel bound to contend that a still further and most

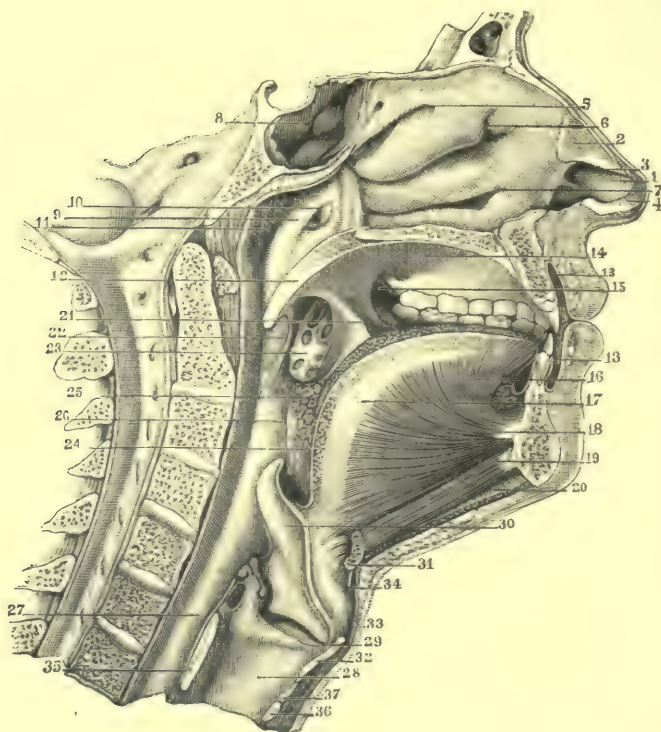


FIG. 112.—MEDIAN SECTION OF THE MOUTH AND PHARYNX. (Sappey.)

1 to 8, relate to parts in connection with the nostrils; 9, upper or respiratory part of the pharynx; 10, aperture of the left Eustachian tube; 11, depression of the mucous membrane; 12, velum palati; 13, 13, vestibulum oris; 14, arch of the palate; 15, space at the back of the dental series; 16, 17, tongue; 18, genio-glossus; 19, genio-hyoid; 20, mylo-hyoid, cut; 21, 22, anterior and posterior pillars of the fauces; 23, tonsil; 24, posterior vertical part of the tongue; 25, its glandular eminences and depressions; 26, 27, lower part of the pharynx; 28 to 37, refer to parts of the larynx; 30, epiglottis.

important, chemico-physiological, process, has to be gone through, synchronously with these, by the alimentary materials, the outcome of which, it is still premature to attempt to estimate, or appraise, but the apparent influence of which—proportioned to its extent, and incidence—must be reckoned, as of *very great* extent and functional

importance. The process here referred to is that of admixture, of the raw alimentary materials, with the lymphoid and colloid excretory juices, exuding constantly from the fauces and tongue, and consisting of the pituitary excretion from the structures known as the tonsils, lateral and central, the uvula, and the whole extent

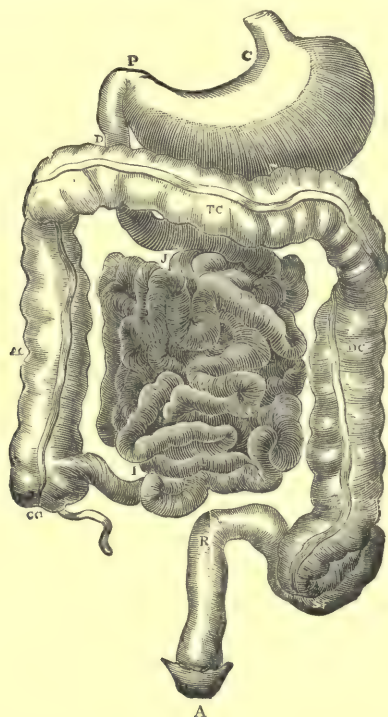


FIG. 113.—DIAGRAM OF THE ABDOMINAL PART OF THE ALIMENTARY CANAL. (Brinton.)

C, the cardiac, and P, the pyloric end of the stomach (this organ is represented in too horizontal a position); D, the duodenum; J, I, convolutions of the small intestine; CC, cæcum, with the vermiform process; AC, ascending, TC, transverse, and DC, descending colon; SF, sigmoid flexure; R, rectum; A, anus.

of the glosso-pharyngeal mucosa (see Figs. 100, 112). It will, we think, become apparent, more and more, as investigation of the subject progresses, that we have here to deal with digestive factors and problems of *no mean* importance arising from the physical admixture and resultant chemical action and reaction of two very dissimilar sets of substances, viz. of the excretory, or

retrospective, results, of brain waste, and the pristine elements of prospective nutrition.

We are warranted, in the meantime, we think, in stating that not only have we to deal here with a digestive phenomenon, but with an excretory process of vital importance in the economy of cerebration, with all that is dependent upon the maintenance of the physiological condition of the central nervous system. All this, of course, being yet heterodox, we can only, tentatively, call the attention of those who are in any way interested in, or practically engaged with problems related to, the subject, hoping that its possible scientific, and practical, bearings, will in time be fully realised.

The œsophagus (see Figs. 112, 113) is, in function, and structure, so far as yet discovered, vehicular, mainly, that is to say, it is a tube, for the conveyance from the pharynx to the stomach, of the masticated, insalivated and *pituitarised*, food, although in certain physiological, and pathological, pouched conditions, opportunities are afforded for the elements of the food, to undergo chemico-physiological changes, of a character dependent on pre-gastric digestion.

The stomach (see Fig. 113), on the other hand, is an adaptation of the lumen of the enteric canal to the requirements of a digestive viscus, which has given a specific term, for use by the "man in the street," as well as the most learned scientist, and which is in greater daily use, than almost any other selected term that could be quoted. It is the first of the long series of digestive viscera, constituting the abdominal development of the intestinal canal, and so important in the economy of the digestive process, that it performs its functions with "closed doors," so to speak, being valved at both ends, and endowed with a powerful musculature, which is innervated by both the systemic and sympathetic nervatures, hence it may be regarded as the most actively functional of all the divisions of the intestinal canal. Its manner and method of working, have been more exhaustively studied, than have been those of any other intestinal division, but it cannot be said, with any degree of truth that the last word has yet been spoken, or written, on the subject; on the contrary,

judging from the past, it seems likely to afford a perennial theme for discussion, by physiologist and clinician alike, until medical science is with sufficient reason, or, at any rate, entitled, to be called exact. The musculature of the stomach is adapted to the performance of, circular, forward and backward, movements, of its contents, in accordance with the necessities, arising during the functional activity of the organ, or thrust on it, from failure of other parts of the intestinal tube to meet their obligations, in the joint work of intestinal circulation, by normal peristalsis. Antiperistalsis is a functional endowment of the gastric musculature, whereby the *vis medicatrix natureæ*, is enabled to effect, the reversal of a possible pathogenic functional current, and to relieve the physiological factors of the necessity of dealing with dangerous elements, alimentary, and others. The gastric musculature is here mainly under the control of sympathetic innervation, and hence is inexorable in its demands on its systemic partner.

The smaller bowel (see Fig. 113), consisting of duodenum, jejunum and ileum, is small in lumen, but much longer than any division of the alimentary canal, and has added to its contents a larger quantity of intra- and extra-mural material, than any other division receives, the liver, and pancreas, besides the local mural glandulature, contributing their entire secretions. The bile and pancreatic juice being added, immediately after the duodenum leaves the pyloric orifice of the stomach, and the glandular secretion of the entire extent of the canal of the smaller bowel, added, as the chyme is circulated onwards, chemical and physical changes are constantly occurring, during the continuance of that circulation, by which it is rendered absorbable by its lining mucosa (see Fig. 113). The stomach having already removed, by osmosis, the more liquid portion of its contents, and prepared the substance of the chyme for digestive treatment, by the smaller bowel, the villi of whose lining membrane are able to absorb, and pass into the capillary terminations of the lacteal vessels, and, necessarily, to some extent, into the blood capillary vessels distributed within it, the materials, which have yielded to the digestive influences here brought to bear on them, with the result, that, only an unyielding

undigested residuum is passed through the ileo-cæcal valve, to be subjected to a still farther digestive process, ere it is ejected, as altogether indigestible.

Posterior to the ileo-cæcal valve (Fig. 115), the intestinal canal is continued as the larger bowel, consisting of the cæcum, with the vermiform process, colon, and rectum, to the anus, where the division, and differentiation, of the neurenteric canal, were originally effected, and where the residual result, of the various digestive processes, to which the elements of the food originally ingested have been subjected, are ultimately ejected. The digestive processes, to which the contents of the larger bowel are subjected, seem to be, in principle, and method, a continuation, and completion, of the long

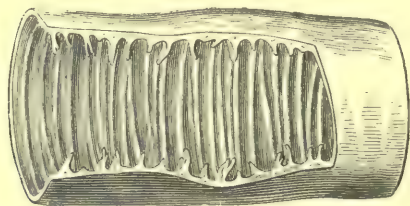


FIG. 114.—PORTION OF SMALL INTESTINE LAID OPEN TO SHOW THE VALVULÆ CONNIVENTES. (Brinton.)

series constituting the physiologically entire process of digestion, and, as is characteristic of the preceding stages, they are conducted with "closed doors," the ileo-cæcal valve, the sigmoid flexure, to some extent, and the anus, constituting barriers, which, in the physiologically healthy condition, are effective barriers.

From this point of view, we think we are warranted in regarding the cæcum as a posterior stomach, in which the residual chylous contents of the smaller bowel are subjected, on their arrival, to a further muscular agitation, during their admixture with the secretion of the vermiform process, a lymphoid material, which is credited with almost negligible qualities, but, nevertheless, a secretion, of as definite, and physiologically decided a character, as those of the liver, and pancreas, and the only secretion, moreover, which empties itself into the commencement of

the larger bowel, and which must, necessarily, be connected with the digestive phenomena occurring therein.

The operation of the law of gravitation, furthermore, keeps the cæcal contents in a position, favourable for admixture with the secretion of the appendix (see Fig. 113), ere they mount the lumen of the ascending colon, and pursue their course along the remainder of that bowel. It is here, in particular, where the most characteristic stercoraceous changes are effected in the alvine contents,

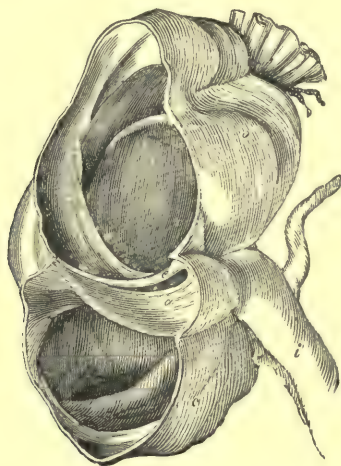


FIG. 115.—VIEW OF THE ILEO-COLIC VALVE FROM THE LARGE INTESTINE.
 $\frac{1}{2}$ (After Santorini.)

The figure shows the lowest part of the ileum, *i*, joining the cæcum, *c*, and the ascending colon, *o*, which have been opened anteriorly, so as to display the ileo-colic valve; *a*, the lower, and *e*, the upper segment of the valve.

but whether these changes are due to ordinary local chemico-physical action alone, or whether this is aided, by anaërobic bacterial activity, it would be premature to speak, still it would seem, not too far-fetched to say, that here the alimentary residuum may perhaps, in order to effect its complete physical disintegration and chemical resolution, in addition to the action of the local bowel digestive agencies, have added a living bacterial agency or "pseudo-phagocytic" organisation, on kindred lines to those of the leucocytes, or white blood corpuscles, in the economy of nutrition. The presence here, of organisms of this character, in ordinary physiological conditions of

health, is at least suggestive of their utilisation in the economy of digestion, as a supplement to the many chemical and physical instrumentalities brought to bear on the preparation of the nutritive pabulum, for intestinal absorption and tissue assimilation.

The larger bowel terminates in what is equivalent to a cloaca, in which, the last chemico-physico-bacterial influences of digestion are brought to bear on the alimentary residuum, in the descending colon, and it seems, to us, more especially anterior to, and in, the sigmoid flexure (Fig. 115), which acts as an inner barrier, or valve, to the immediate farther progress of that residuum. We are further of opinion, that this inner anatomical barrier, or valve, is utilised as a pre-anal protective agency against the continuous forward peristaltic movement of the bowel contents, and as a means of prohibiting and preventing peristalsis of the anal portion of the rectum; peristalsis of which, it seems to us, is produced, or allowed by relaxation of this inner sphincter, and the invasion of the pre-anal gut (Figs. 113, 115), by the faecal contents of the descending colon and sigmoid flexure. The sequence of the phenomena of defecation, moreover, seems to be initiated, in the ordinary physiological conditions of the structures, and their functions, by a continuation of pre-sigmoid peristalsis, along the wall of the pre-anal part of the rectum, which, as the alvine material is passed onward into the lumen of this part of the rectum, reflexly stimulates the systemic nervature of the anal orifice of the bowel, with the result that the anal sphincter is relaxed, and aided, when required, by the voluntary musculature of the abdominal walls, the expulsion of that portion of the excreta, lying between the inner and outer sphincters, is thereby effected.

It may be that this inner sphincteroid provision, which we have called a fæcimeter, is due, largely, to mechanical obstructive circumstances, from flexure alone, but we are disposed to regard it as being aided by anatomico-physiological adjustments and structural adaptation, and that the effect of its operation is the saving of continual discomfort and distress, and the rendering of everyday life experience, not only bearable, but securely safeguarded.

In this connection, it may be held as a rule that the quantity of each alvine evacuation is determined by the quantity containable, consistently with the absence of local discomfort, within the post-sigmoid portion of the

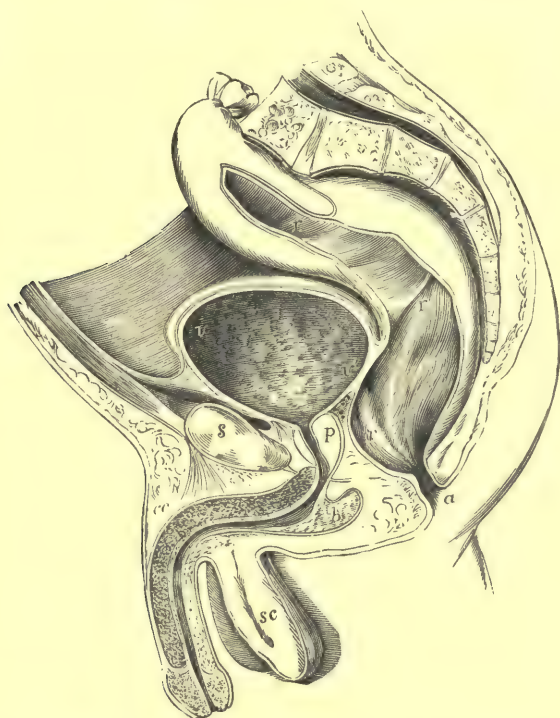


FIG. 116.—VERTICAL SECTION OF THE PELVIS AND ITS VISCERA IN THE MALE. $\frac{1}{2}$ (Allen Thomson, after Houston.)

This figure is introduced to illustrate the form, position, and relations of the rectum; it also shows the bladder and urethra with the pelvic inflection of the peritoneum over these viscera: *r*, *r*, *r*, the upper and middle parts of the rectum, and at the middle letter the fold separating the two; *r*, *a*, the lower or anal portion; *v*, the upper part of the urinary bladder; *v'*, the base, at the place where it rests more immediately on the rectum; *p*, the prostate gland and prostatic portion of the urethra; *b*, the bulb; *c*, *c*, the corpus cavernosum penis and suspensory ligament; *sc*, the scrotum; *s*, symphysis pubis.

rectum, and that the consistency of its substance, or material, and the responsiveness of the combined machinery of evacuation, determine the manner, and method, of its ultimate elimination, or excretory disposal.

In connection with the assignment of sphincteroid powers, to the anatomical mechanism of the sigmoid

flexure, we would draw attention to the fact that a quantity of gas is always present locally, and generally, throughout the intestinal tract, and is dependent for its presence on several causes, amongst others, to the following, viz. air swallowed with the ingesta, gas generated by chemico-physiological, or digestive, action and reaction, and gas emitted from the bowel mucosa, but, from whatever, or all, of these causes, there is always, in a physiologically healthy state of the parts, a quantity, sufficient more or less to balloon the bowel, and secure free passage to its contents. Needless to say, this gas is, more or less, locally confined, within the compartments into which the intestinal tube is divided, and moved, from compartment to compartment, by the ordinary peristaltic action of the bowel wall, having to leave its lumen, when incompatible with bodily comfort, by relaxation of the cardiac valve of the stomach, and anal sphincter, situated, respectively, at its two extremities—That the “ballooning” of the bowel is a function of nothing less than vital importance, must be apparent to every one who has had an opportunity of witnessing the phenomena in others, or has attentively analysed his own sensations, in relation thereto. We need only observe, therefore, that peristalsis, and anti-peristalsis, are in constant operation to effect the phenomenon, and that a feeling of absolute comfort in the neutral region is possible only when the lumen of the intestinal tube is equally relaxed, or at rest, or contracting on its contents, without their undergoing more than the normal amount of obstruction to their forward, or backward, passage. In all the activities of the bowel wall, it is a primary necessity that a normal quantity of ballooning materials should be present within its lumen, in which condition the bowel musculature is supplied with a continuous “fulcrum,” so to speak, on which *it can support itself* in its continuous, staltic, or vermicular, disposal of its contents, solid, liquid, and gaseous.

During active stalsis, both peri- and anti-, it may be that considerable discomfort ensues, and when acutely localised, a condition of violent spasm, or cramp, of the bowel musculature is the result, also, that in minor degrees of that discomfort, in the almost normal “state

of things," for instance, when a mere local increase of "flatus" obtains, the positions usually assumed, or affected, agree with the positions of the principal sphincters of the intestinal canal, viz. the cardiac, and pyloric, the ileo-cæcal, the sigmoid flexure, and anal sphincter.

When morbid obstructive bowel phenomena have to be practically dealt with, it becomes *absolutely necessary* to bear these elementary facts in memory.

The adaptation, therefore, of the anterior limb of the V-shaped neurenteric canal, to the requirements of an apparatus, for the preparation of alimentary materials for nutritional purposes, may be regarded as transcendently complete, and absolutely adapted, to meet its every requirement, from whatever aspect its details, individual, and communal, can be viewed. It need scarcely be added that the posterior limb of the neurenteric V is the only other evolutionary product, in its finished state, in any way comparable, in its details, and adaptation, to functional purposes, which can be met with in the whole course, and history, of evolution, organic, or inorganic. We cannot, therefore, but regard these two neurenteric evolutionary products as the "crown, and head" of the *anatomical sequence*, reaching from the amœba to the last vertebrate, and from the first to the last of that great biological ascent, or descent, known to natural science and revelation alike, as "life on earth." In this connection, it only remains to add that these two divisions of the neurenteric canal, in their fully evolved condition, of structural, and functional, fitness, are fitly joined together, and operated, by the great *dynamic organism*, the heart, and blood vasculature, with the result, that the greatest biological wonder in our world, thus, becomes accomplished, and visible, in the form of man, with all his attributes, and aspirations, his physical, and mental, faculties, his powers to realise the past, and the present, and his ability, to some extent, to grasp, and anticipate, the future, as well as to evolve, and apply, the principles of justice, ethics, and morals, in relationship to himself, as well as to his fellow-men.

Digestion, thus, is a very long, and complicated, process, combining, as it does, the use of mechanical, chemical,

and physiological, agencies, and the use of absorptive media, adapted to the transference of the digested material, from the intestinal canal, to the various vasculatures leading to the central, or blood, circulation : in which, it but illustrates the truth we have contended for, namely : *circulatio circulationum omnia circulatio*, and that oneness of design, or purpose, and continuity of operation of the various means devised for the accomplishment of it, mark its every stage,—Thus, the mechanical trituration of the articles of food is accomplished, simultaneously, with their softening and partial liquefaction, as well as their admixture with the chemically-reducing agencies of saliva, and the linguo-tonsillo-pharyngeal cerebro-spinal, residual and, perhaps, fermentative excretion, which they gather from every papillary, height, and hollow (Fig. 112), as they are buffeted from side to side in measured mastication, or eddy round the tonsillar promontories, encircle the pendulous body of the uvula, as they drag past its obstructing presence, or as they impinge on the cavernous walls of the pharynx, ere they are plunged into the narrow lumen of the œsophagus, lined by a mucosa, from the surface of which is detached, by their passage, a viscid fluid, which, in turn, must necessarily add to the digestive agencies already at work, in the accomplishment of the great common end. Reaching the stomach (see Fig. 113), another, and the greatest, chemical influence, is brought to bear, on their reduction to a state of fluidity, and chemical composition, suitable for trans-sudation through the gastric wall, preparatory to the production, and transmission, of the residual, or resultant, chyme, into the small intestine, where admixture with physiologically elaborated juices, and ferments, breaks them up into a state of physical consistence, or chyle, suitable for absorption by its lining mucosa (Fig. 114), and circulation through its related lacteals. During the operation of these agencies, a remainder is left, which has resisted their combined, mechanical, chemical, and physiological, influences, and which, in turn, is ushered into the larger intestine, to be subjected to further reduction, and disintegration, in order to fit it for passage through the meshes of the surrounding mucosa, and this is accom-

plished, amongst other proper large bowel agencies, by admixture with the appendicial secretion, loaded with the *bacillus coli communis*, which latter, in our opinion, exercises an actually, living, and specific, influence, on the passing residuum, breaking it up into impalpable pabulum, so to speak, in which state, it finds the requisite passage, through the large bowel wall into the proper receiving vasculature, leaving the irreducible remainder, to find its way to the sigmoid flexure of the descending colon, for fæcimetric transmission into the rectum, to be finally "searched" for still remaining nutritive elements, and made into parcels for convenient disposal, as altogether unutilisable. These stages, and factors, may be said, to constitute a short syllabus of the long process of digestion, or a bird's-eye view of the first, or alimentary circulation.

EXTRACT XXV. B.

ON THE SIGMOID FLEXURE OF THE COLON.

THE sigmoid flexure (see Figs. 113, 115), as already implied, represents an anatomical device of the highest functional value, and an evolutionary product due largely to the assumption of the erect position by the members of the human race and the consequent necessity for the provision of an automatic or self-acting and regulating alvine, circulatory, and evacuant machinery, whereby the "calls of nature" can be conveniently controlled and organised to meet the necessities, amenities, and complex requirements of man's higher individual and social destiny.

Thus viewed, the sigmoid flexure represents, in a highly conspicuous degree, the anatomical evolution of structural adaptations to changing functional requirements, as these alter and increase, to meet altering generic needs—thus the horizontally poised and quadrupedally progressing animal is not "on all fours" with its related erect and bipedally progressing human neighbour, and hence does not display that more elaborate and, so to speak, more finished disposition of its enteric canal, that is to be observed in the latter. This distinction, no doubt, is due to the combined influence of the altered nature and manner of their respective alimentations and the position of their respective alimentary organs, in relation to gravity and the position of the orifices of inlet and outlet of the alimentary and residual materials current in their nutrition ; thus, the nearest mammalian relations of man usually possess excretory orifices at points, generally speaking, superior to or on a level with, although sometimes, from functional necessity, etc., below, the

orifices of inlet, all which is in consonance with the anatomico-physical necessities of their horizontal position and the simpler physiological conditions involved in their case. Man, on the contrary, in consequence, it seems to us, or on account of, his vastly altered position in regard to inlet and outlet levels produced by the assumption of the erect position in his "daily walk," and the involved disturbance in level of these orifices, has thereby begotten a necessity for an altered disposition of his alimentary canal, and so the introduction of specific differences in the manner of providing for and effecting the function of excretion has marked his attainment. Here, then, we contend that we are warranted in claiming the duplication or folding of the lower bowel, known as the sigmoid flexure, as a great mechanico-physiological adaptation of the intestinal tube to meet altered conditions as to anatomical position of the human body and the changed operation of the law of gravitation in relation thereto. Thus, the fascial pelvic structures constituting the floor, instead of merely guarding the posterior aspect and extremity of the body, become a real pelvic floor, on which is supported the superincumbent abdominal viscera and the dependent area through which the great excretory organs effect an outlet, it therefore follows that a great evolutionary work has been accomplished in the adaptation of means to ends herein necessitated. In this evolutionary sequence of events the adaptation of the intestinal canal to withstand the influence of gravitation by automatically acting mechanical means, while leaving the intestinal tube, nominally patent, to convey, as formerly, its contents in obedience to physiological law and necessity, stands out in our estimation as one of the most manifest examples in the whole range of later anatomical design. Thus we have seen the alimentary canal converted from a horizontally, albeit zig-zagly, disposed canal, to a perpendicularly arranged tube, without a fundamentally altered plan—that canal, as altered, resting at its lower extremity on the pelvic floor, duplicated or folded, so as to provide an automatic means of preventing overflow, or outflow, while allowing the function of peristalsis to be effected as before, with the super-added advantage of safeguarded, but uninterrupted, alvine

expulsion, by the principle, as before stated, of a "fæci-meter," or alvine regulator.

The alimentary or intestinal canal in both instances is held in position by a series of anatomical structures variously disposed and adapted to maintain its horizontality or perpendicularity as the case may be, while providing for its divisional and general patency, and securing, in stages, the performance of its functional work, by the provision, in its lumen, of a series of "shut" or valved "sacs," in which the particular acts of digestion are carried out *seriatim* and the process of nutrition ministered to.

These supporting structures and divisional dispositions of the canal are known to anatomists by various names, and when seen in whole, and regarded from the point of view of design, and as effective adaptation of means to ends, inspire the observant student as he, however slightly, realises their import, with a feeling akin to that of the astronomer when he succeeds in unravelling the details of a solar system, or the terrestrial explorer when he discovers a "dark continent."

Beyond this fæci-meter, or alvine regulator, is the last, or concluding, compartment of the intestinal canal, known as the rectum (see Figs. 113, 115) from its straight disposition, a pouch, or alvine chamber, in which, as in a cloaca, the residual alimentary materials quickly or slowly accumulate for periodical discharge under, more or less, the voluntary control of the individual, through or by the aid of the systematically innervated anal sphincter, and associated abdominal expulsatory musculature.

Conducing to the functional facility of intestinal evacuation is the moistening, or lubrication, of the intra- and extra-anal, and proper rectal structures, effected by the posterior outfall agency of the cerebro-spinal fluid, where it empties itself from the coccygeal gland apparatus (see Fig. 113), in the manner elsewhere described, and where it seems to us to maintain the structural and functional continuity of the once undivided embryonic neurenteric canal, and to demonstrate the subsequent oneness of the great circulatory economy existent amid the permanent and final structural dispositions and visceral differentiations of the adult body, as they have directly descended from,

and been determined by, embryonic development and evolution.

In the surgical and other means, therefore, had recourse to in the treatment of diseases of this region, these facts, we would call them, should not be overlooked, but allowed to have that consideration which their importance demands, and their immediate applicability entitles them to. Moreover, the appreciation of these facts will enable militant medicine to meet the requirements of many cases on more thoroughly scientific principles than have hitherto characterised its procedure here, and so the services of surgery may be obviated and its objects gained by less heroic and more natural means, as well as in a more—from the patient's standpoint—grateful manner.

In concluding our review of the knowledge, general and special, existent at the present time, or any time within the past half century, we would conclude, so far as our appreciation of such a wide subject will enable us to do, that the subject of alimentation has not yet advanced in its scientific appreciation to more than its elementary stage, the elements composing that stage having, to a great extent, still to be gathered from physiological, pathological, and clinical sources, accessible only with difficulty to the general enquirer; hence, we regard it as incumbent on those interested in such a vital subject to collect and focus all their information bearing directly and indirectly on its elucidation, in order to be enabled to deduce its fundamental and specific principles, with a view to ensure the scientific application of regulative and ameliorative means wherever, and whenever, the necessity for their use may arise.

We know enough, however, to warrant us in claiming for the machinery of alimentation a completeness of adaptation to its purpose as absolutely perfect as is to be found throughout nature, a oneness of aim and object as complete as structure and function can effect, and hence a continuity of physiological working which it is essential at all times to maintain, and, when faulty, to rectify, on lines consistent with the necessity of the individual instance.

In addition to what has been said of the special mechanical adaptation of the *sigmoid flexure* of the large intestine to fulfil the functions of an internal sphincter and fæcimeter—

we might assign to, or claim, for every flexure of the bowel a kindred function, or kindred functions, and advance the general opinion that the valvular structures, or mechanisms, marking the beginning and end of its various intestinal divisions, safeguarding the specific functional work of the stomach, small and large intestines, are aided every instant of their working time by a *peristaltic flexuring* of the bowel tube, or intestinal canal whereby an effectual functional treatment of the alimentary materials is obtained with the greatest certainty, and the easiest passage, so far as dynamic expenditure is concerned, along that canal—peristalsis maintaining, on the part of these materials, a position in which “gravitation” can be made available to the greatest extent, and consequently with the least dynamic expenditure or waste on the part of the bowel musculature. Thus, the peristaltic wave of muscular contraction of the bowel wall carries on the flood of alimentary materials with a greater, or lesser, approach to inclined, or horizontal, wriggling and moving in a serpentine manner, and so utilising for functional purposes every fraction of the prolonged intestinal mucosa, each great intestinal division, or viscus, delivering to another, readily prepared, the material for its specific functional work—to the one great functional end, that of the preparation of the food for nutritive purposes, in which all the anatomical structural characteristics of the alimentary canal, the physiological contrivances, the dynamic expenditure, and the physico-chemical interchanges of the alimentary materials combine with the “ordinary statics and dynamics of nature” in preparing for nutritive consumption and metabolism what experience and reason dictate to each individual man and woman is the food they require, or it may be they are compelled by circumstances to take.

The alimentary canal, as a circulatory apparatus, is surely one of those transcendently adapted for its purpose, and showing evidences of design of the most elaborate and succinct character throughout every stage and division of its entire extent ; indeed, it is only equalled by that which is apparent throughout the whole extent of the posterior limb of the embryonic neurenteric **V**, and an unmistakable example of the truth : *circulatio circulationum omnia circulatio*.

EXTRACT XXVI.

ON THE NEUROGLIA, AND HOW, AND WHEN, THE ELEMENTS OF THE INGESTA BECOME ALIVE.

IN dealing, here, with the more solid parts of the nervous system, let us begin with the substance known as the neuroglia, the most largely developed structure entering into the composition of the brain, spinal cord, and ganglia.

The neuroglia may be looked upon, as the scene of the great problem of what may be described as a *secondary digestion, and assimilation*, *i.e.* the cerebro-spinal, or central, as well as the peripheral, nervous system, may be regarded, so to speak, as a product of, or, at any rate, as having been developed within, and from, that structure—in other words, the blood arterio-capillary circulation terminates, so far as its nutritive function is concerned at least, within that structure, and leaves the brain portion of it, by the vessels known as the sinuses (Fig. 117), *i.e.* it conveys hither the materials, from which the nerve cell structures, or neurons, are developed (Figs. 117, 118), and by which they are nutritionally, as well as mechanically, sustained, and, therefore, the neuroglia, thus, becomes the *storehouse*, to which the raw materials are conveyed, and from which the nerve structures select what they require for their, development, maintenance, and repair. Hence it may be regarded as the great terminus, to which the circulation proper, or a section of it, is constantly engaged conveying nutritive material, whence it can be taken up, and distributed, to meet the requirements of the great systemic nervous system—and this latter, the systemic

“nervous system” itself, may be regarded, as necessitating, and forming another and distinct circulation, or series of circulations, a large part of which, the cerebrospinal, has been already described. Thus, the neuroglia, which is partly granular, and partly amorphous, inter-

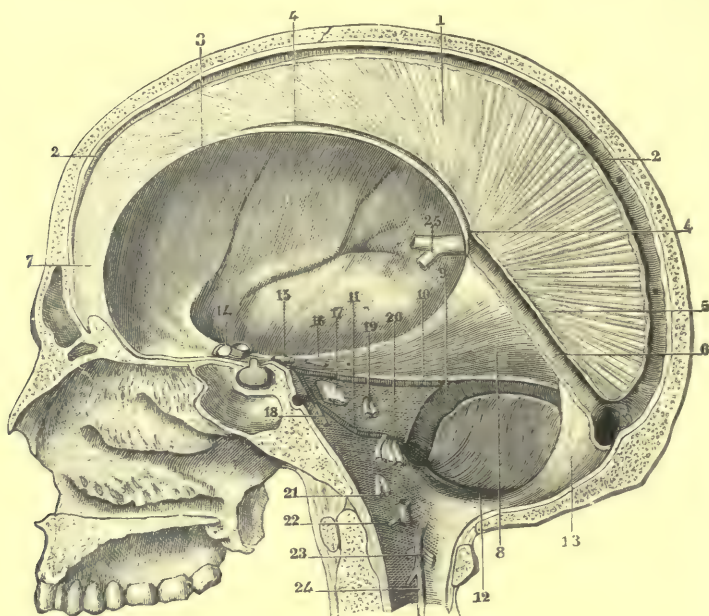


FIG. 117.—THE CRANIUM OPENED TO SHOW THE FALX OF THE CEREBRUM AND TENTORIUM OF THE CEREBELLUM, AND THE PLACES OF EXIT OF THE CRANIAL NERVES. $\frac{1}{2}$.

1, falx; 2, superior longitudinal sinus; 3, concave border of the falx; 4, inferior longitudinal sinus; 5, base of the falx; 6, straight sinus; 7, anterior part of the falx; 8, right side of the tentorium cerebelli, seen from below; 9, lateral sinus; 10, superior petrosal sinus; 11, inferior petrosal sinus; 12, posterior occipital sinus; 13, falx cerebelli; 14, 15, 16, 17, 18, second, third, fourth, fifth, and sixth cranial nerves; 19, seventh and eighth nerves; 20, ninth, tenth, and eleventh nerves; 21, twelfth nerve; 22, 23, first and second cervical nerves; 24, upper end of the ligamentum denticulatum.

penetrated, and supported, by a fibro-cellular meshwork of very fine texture (Fig. 119) is at once, the physical foundation, or basis, on which the component neurons of the systemic nervous (see Fig. 117) system rest, from which they grow, as plants do from the soil, from which they extract their nutriment, and to the support, and integrity, of which, all the organs, and structures, of the body,

labour, and are kept in being. The systemic, or central, nervous system, may thus be regarded as the innermost texture of our being, and the "sanctum sanctorum" of the "mind, and spirit," or the scene of the transcendental

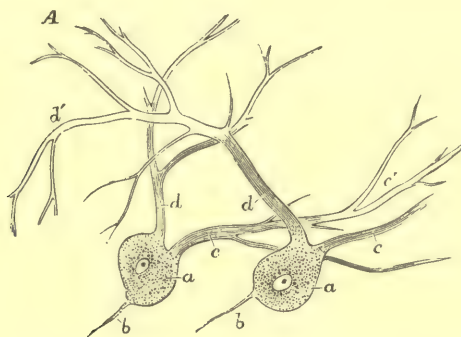


FIG. 118.—TWO NERVE-CELLS FROM THE CORTICAL GREY MATTER OF THE CEREBELLUM. Magnified 260 diameters. (Kölliker.)

union, of mind, and body, where the great mysteries of "being," the "mystery of mysteries," lie, wrapt up, and enshrouded.

The neuroglia, as thus described, may be claimed as the great emporium, of brain, cord, and nerve, pabulum, or plasma, deposited from the blood circulation, as it permeates the feltage of the glial fibro-cellular reticulum, or matrix, where, also, a proportion of the *liquor sanguinis* escapes into the peri-vascular spaces, to become continuous, in circulation, with the peri-saccular spaces, extra- and intra-cerebro-spinal spaces, and peri-neural channels, as the fluid, known as cerebro-spinal. It, the neuroglia, forms, thus, the great bulk of the substance of the brain, cord, and ganglia, and before it has been utilised by the various neurons composing these great structures, it may be called an absolutely non-nervine substance—hence the impunity with which the neuroglial matrix can be disturbed, or destroyed, by foreign bodies, or traumatic agencies,

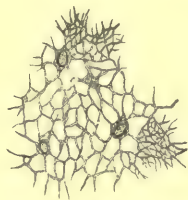


FIG. 119.—PART OF THE RETICULUM FROM THE SPINAL CORD. (Kölliker.) Magnified 350 diameters.

without fatal consequences, in contradistinction, to the fatal effects following destruction of neuronal structures.

Nevertheless, it is even then, we may take it, a substance highly energised, or potentially charged, and capable, with neuronal metabolism, of meeting the physiological, and psychological, requirements, of every neuronal unit of the great central nervous system, material, and dynamic. It may, therefore, be described as the highest, and most finished, example, so to speak, of nutritive pabulum, or plasma, to be found within the organism, and, from its enormous total quantity, it may be looked upon as never failing in its immediate availability, and utility, in all metabolic emergencies, arising within the systemic nervous system, and to some extent, no doubt, within the attached, and continuous, sympathetic nervous system, at least within the *debatable* area supplied by the joint, or contiguous, metabolic machinery, and plasma, of the two systems.

Its quantity, and quality, when viewed from the standpoint of nutritional necessity, must also be regarded, as absolutely meeting the various requirements of one great nervous system, developed within, and by, another great nervous system, which latter, being sustained by constant supplies of raw, but adaptable, materials, drawn from the outer world, in turn converts them into suitable pabulum for the former, to be utilised by it, where, and whenever, required, by its infinite multitude of neuronal units, individual, and grouped.

Neuroglia, thus regarded, must be looked upon, as the most essential of all the secretions—for we must rank it as such—of the body, for from, and on, it, grow the entire neuronal elements of the systemic nervous system, with their histological continuations of, muscular, osseous, and dermal, developments, in other words, of all the non-sympathetically innervated structures, motile, and æsthetic, or of the structures evolved from the original ectoderm.

Besides being the most essential of all secretions, it lends itself to a continuation of the secretory process, in that it becomes utilised by the various neurons, through absorption by their dendritic processes, metabolism of their cell mechanism, and histological growth along their

axons, with ultimate terminal incorporation with the musculo-skeletal, and dermal, tissues, and final, disintegration, and elimination.

If we accept these views, can we wonder at the mental strength so often maintained, when bodily weakness has taken possession of the organism? We unreservedly say, we cannot, inasmuch, as when the neuro-musculo-dynamic machinery has been almost entirely switched off from the sensory, and motor, centres, we are logically and physiologically, compelled to believe that the mind can, for long periods subsist, more or less completely, on the large passive reserve, stored up within the great materio-dynamic repository of still unused neuroglial plasma, and energy, and that intellectual cerebration can, so, be continued, until the stage of absolute dynamic exhaustion has been reached—when, as in long-continued fever, entire unconsciousness may set in, and reign, until the great sympathetic nervous system determines, whether it is capable of still maintaining life, and of renewing the régime of systemic innervation, and conscious cerebration.

As the meso- and hypo-dermal tissues extract, and metabolise, their nutritive supplies, directly, or indirectly, from the all-pervading blood streams, so do the ectodermal tissues extract, and metabolise, theirs from the neuroglial matrix, the one being as essential, as the other, in rendering possible, the performance of their respective functional rôles, and systemic work. These two great passive elements, the blood, and the glia, representing, respectively, the storehouses, so to speak, from which the two great nervatures of the body draw their materio-dynamic supplies, and convert them into work, and unutilisable residuum.

The *pia mater*, on which the neuroglia is dependent, for the peculiar nutritive material, on which the neurons live, and grow, and for the supply of that peculiar lymph, which encircles, and inter-penetrates, the sponge-like structure of the entire systemic nervous system, finds, prepared for the scene of its anabolic work, a superlatively finely meshed basic (see Fig. 119) texture, or feltage, of cellulo-fibrous formation, amid the interstices of which it deposits that peculiar nutritive material, or glia, and through whose

fine meshes it allows to percolate, and escape, the more liquid elements resulting from the process, into the inter-spaces, and channels, coursing through the neuroglial matrix. Occurring in this cerebro-spinal, and ganglionic, process of deposition, by the *pia mater* vasculature, of this plasmic, almost amorphous, material, and the draining, or running off, from it, of its more fluid constituents, it will be apparent, that a certain proportion of that amorphous material will, or must, find its way, where it is scarcely fluid enough to pass along the intra-glial inter-spaces, and channels, into the lymph byways, and highways, for elimination, by the proper neuro-lymph excretory organisms, and agencies; hence the clogging, and perhaps stoppage, of the intra-glial lymph circulation, may become a pathogenic influence, and lead to the production of nervine ailments, of the most profoundly cryptic character, as well as, of the most clearly defined, mal-circulatory, conditions, in central, and peripheral, nervine regions.

In estimating the extent, and manner, of incidence, of nervine ailments, in all their categories, it will be well to bear in mind, that the neuroglial matrix of brain, cord, and ganglia, is composed of, structurally speaking, four elements, viz. glia proper, fibro-cellular basic tissue, blood vasculature, and neurons, besides the cerebro-spinal lymph, and that these, in a physiologically exact proportion, may vary within certain definite limits, and that, if these limits are passed, the elements of friction, or morbid, inter-elemental influence, begin to work, and that the result, or end, of that friction, may be, and possibly must be, pathogenic—it, therefore, behoves everyone, engaged in the clinical department of neurological medicine, to take advantage of that knowledge.

We have little doubt, that much of the pathological interference with cerebral, spinal, and neural, function, is due to faulty proportions of these aliments, and to mal-circulation of the cerebro-spinal lymph, and that remedial measures, to be successful in rectifying the faulty condition, must be based largely on their thorough appreciation, and the therapeutic, and other, indications, flowing from that appreciation.

This knowledge, grafted on a thorough, and sound,

familiarity, with the latest, and best, neurology, will, we are convinced, bear excellent fruit, in the fields of both general, and psychological, medicine, and will aid in securing for these, as science, a position of greater, exactitude, and respect.

The neuroglia is, thus, the basal plasmic nerve substance, or texture, and occupies a very large proportion of the space designed for the accommodation of the proper nervine structures known as the brain and spinal cord, besides the intra-ganglionic textures of the systemic, as well as, sympathetic, ganglia. From the formidableness of its proportions, and the inwardness, and centralness, of its position, we would suppose, that its functional rôle must be large, complex, and subtle—mechanically, it constitutes the padding, and stuffing, so to speak, with which the inter-neuronal spaces are kept “inflated,” or occupied, and the contained, or interposed, neurons, sustained in structural completeness, and individuality, without endangerment from collision, or friction, with each other, or lethal contact with their general environment; physiologically, we hold, it constitutes the great emporium, or storehouse, from which the nutritive wants of the systemic nervous system are supplied; and physically, it is composed principally of what may be described, as metamorphic or nutritive, materials, ranging in pseudo-organised consistence, or development, from the almost amorphous, to the somewhat corpuscular, in which condition, or state, it is broken up, and absorbed, by the amœboid activity of the dendritic processes of the various nerve cells, and licked into the condition of nerve cell protoplasm—while, supporting, and sustaining, all, there is, in turn, a fibro-cellular framework (see Fig. 119) of the finest, and most delicate, tissue known, within the meshes of which, are deposited from the blood capillaries, the neuroglial elements, to be arranged, kept vitalised, and stored, for the future use of the systemic neuronal economy, when, and wherever, required.

The almost amorphous, or minutely particular, condition, of a large part of the neuroglial elements, thus renders, for their retention, or storage, in a position

where they are immediately accessible, and available, for neuronal pabulum, the provision of *this unusually* finely meshed containing texture, or feltage, which is porous enough to permit a free, and untrammelled, functional activity, of the contained nervous elements, and the uninterrupted circulation of the cerebro-spinal fluid. Needless to say, all these provisions are, or have been, marvellously secured, within the apparently almost homogeneous matrix of the neuroglia, and facilities allowed, whereby its unutilised, and effete, residuum, can be removed, and its peri-vascular, and peri-cellular spaces, kept occupied by a yielding medium of cerebro-spinal fluid, capable of meeting the exigencies of contraction and expansion.

We, therefore, find, within the texture of this quasi-homogeneous basal elementary nerve substance, a complexity of physico-histological arrangement of its constituent matter, and a system of the most elaborate circulatory inter-spaces, and channels, provided, whereby the nutrition of its contained neurons is secured, and a vital hygienic régime maintained, amid which, the high, and varied, functions of brain, and nervous system, can be performed, without jar, or hindrance, with the maximum of ease, and the minimum of friction. In this region of bodily calm, nevertheless, what mental, and nerve, storms, may, and do, at times prevail?

The vital process, or manner, of procedure, involved in the transference of neuronal pabulum, from the capillary blood circulatory media, to the nerve cell textures, represents the first stage, of the *last great nutritional rearrangement*, and disposal, of organised matter, in the "*round of the changes*," constituting its life-work, and history, within the body. The *pia mater* circulatory textures, ooze, distil, or filter, into the inter-spaces of the neuroglial feltage, the amorphous elements of the neuronal pabulum, where they remain, in pristine, or perhaps faintly organised, form, fit for dendritic imbibition, nerve cell disposal, and nerve protoplasmic formation, along with the cerebro-spinal lymph, or fluid, closely allied to the *liquor sanguinis* in chemical composition, and no doubt derived from it, and continuing, like it,

to exercise, we cannot help thinking, a *preservative influence*, in virtue, we may presume, mainly of its chloride of sodium, acting on the *faintly vital* constitution, and non-, or slightly-, organised, neuroglial substance. In this process is perpetuated, the operation of the principle of circulation, or the *onward flow* of living matter, in its progress, from the less organised, to the more organised, condition, and is displayed what, without exaggeration, may be denominated, a second digestion, and assimilation, the first consisting of alimentary, and the second of neuroglial, and neuronal, phenomena, and each affording the starting-point for new organic arrangements of matter, and the formation of new structural, and organic, elements—the earlier, or alimentary, digestion, furnishing the nutritive pabulum for the growth, and sustenance, of the sympathetic, or non-systemic, nervous elements, of the bodily textures, while the latter, or neuronal, digestion, supplies the more elaborated, and highly potential, elements, for the growth, and sustenance, of that truly wonderful compound of materio-dynamic organisms constituting, what is known as, the brain (Figs. 120, 121), and nervous system, wherein dwells, and works, for good, or for evil, the presiding mind, and immaterial essence, of man.

In this process of secondary, or neuronal, digestion, the nerve cells, by their dendrons, take up, and assimilate, what is required for their own individual support, as well as what is required for the maintenance of their contained nuclei, and nucleoli, and pass it out, or excrete it, as neural protoplasm, along the lumina of the cavities, tubes, or inter-spaces, within the containing walls, or neurokeratinous sheaths, “of the white substance of Schwann,” and the axis cylinders, of their axons, respectively. In our opinion, we are entitled to regard this, as a process of growth, or circulation, along the channels, or spaces, enclosed by the sheaths, respectively, of the medullary, and axis cylinder, substances, which ends in organised exudation, at the terminal extremities, or peripheral arborisations, of the various nerve fibres, sensory, and motor.

Whether the rate of progress of this growth, or circulation, is equal, or approximately identical, in the two

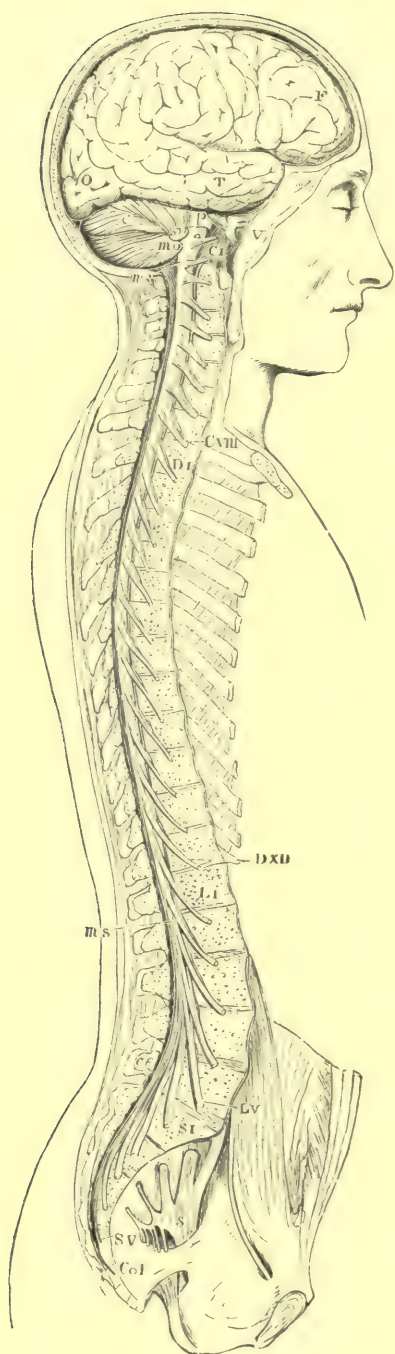


FIG. 120.

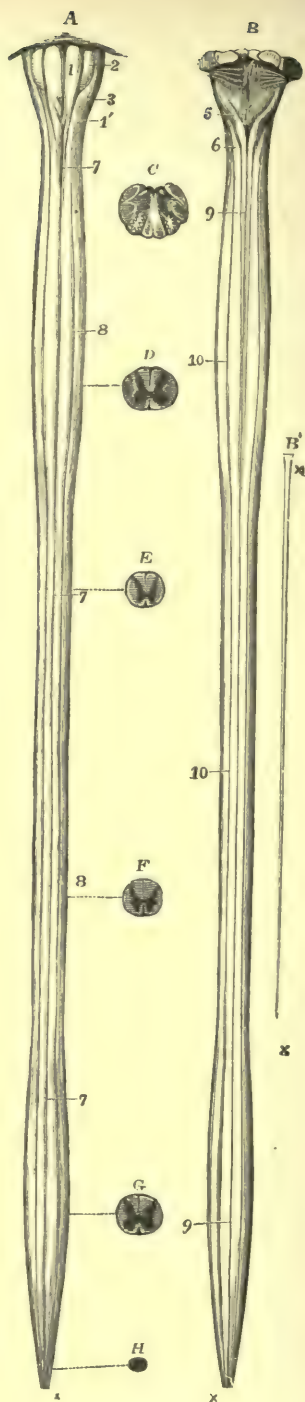


FIG. 121.

protoplasmic products, of the cell, and nucleus, respectively, it would be hazardous to guess, nevertheless, we think there is evidence to demonstrate that it is not alike, as is to be seen in a well-known illustration at page 310 of Quain's *Anatomy* (tenth edition), where the axis cylinder has projected its substance, to a considerable distance beyond its surrounding, and accompanying, tubule of white, or medullary, substance. This may, of course, be due to the different, or variant, action, of the reagents employed, on the differing structures of the medullary and axis cylinder protoplasms, respectively, but it, at any rate, proves, that these two substances, *can move at different, and independent rates*, under the influence of like stimuli, or reagents. The sequence of the material changes occurring in the neuro-metabolic digestive procedure thus described, represents a process of developmental ascent from the elementary, or non-organised, to the organised, or complex, and is attributable to the operation

FIG. 120.—VIEW OF THE CEREBRO-SPINAL AXIS. (After Bourguery.) $\frac{1}{2}$.

The right half of the cranium and trunk of the body has been removed by a vertical section; the membranes of the right side of the brain and spinal cord have been cleared away, and the roots and first part of the fifth and ninth cranial nerves, and of all the spinal nerves of the right side, have been dissected out and laid separately on the wall of the skull and on the several vertebrae opposite to the place of their natural exit from the cranio-spinal cavity.

F, T, O, cerebrum; C, cerebellum; P, pons Varolii; *mo*, medulla oblongata; *ms*, *ms*, point to the upper and lower extremities of the spinal marrow; *ce*, on the last lumbar vertebral spine, marks the cauda equina; *v*, the three principal branches of the nervus trigeminus; *C*1, the sub-occipital or first cervical nerve; *CVIII*, the eighth or lowest cervical nerve; *D*1, the first dorsal nerve; *D*XII, the last dorsal; *L*1, the first lumbar nerve; *L*v, the last lumbar; *S*1, the first sacral nerve; *S*v, the fifth; *Co*1, the coccygeal nerve; *s*, the left sacral plexus.¹

¹ The relation between the bodies and spines of the vertebrae and the places of attachment of the nerve-roots to the cord is also illustrated by this figure. For more detailed information on this point the reader may consult Gowers, *The Diagnosis of Diseases of the Spinal Cord*, 1880.

FIG. 121.—ANTERIOR AND POSTERIOR VIEWS OF THE MEDULLA OBLONGATA AND SPINAL CORD WITH SECTIONS. (Allen Thomson.) $\frac{1}{2}$.

The cord has been divested of its membranes and of the roots of the nerves. A is an anterior, B a posterior view. In these figures the filiform prolongation, represented separately in B', has been removed; C shows a transverse section through the middle of the medulla oblongata; D, a section through the middle of the cervical enlargement of the cord; E, through the upper dorsal region; F, through the lower; G, through the middle of the lumbar enlargement; and H, near the lower end of the conus medullaris.

1 to 6 refer to parts of the medulla oblongata; the remaining numbers to parts of the spinal cord.

1, pyramids; 1', their decussation; 2, olivary bodies; 3, lateral columns; 4, posterior surface of the medulla oblongata; 4', calamus scriptorius; 5, funiculus gracilis; 6, posterior lateral columns passing to the side; 7, 7, anterior median fissure of the spinal cord; 8, 8, antero-lateral impression corresponding to the attachments of the anterior nerve roots; 9, 9, posterior median fissure; 10, 10, postero-lateral groove; X, tapering extremity of the cord; X, X, in B', filum terminale.

of sympathetico-systemic nerve force, or energy, on twice digested matter, within jealously bounded lines, and essential conditions, which eventuates in the evolution of the highest type of structure, or organism, known to science. All preceding processes of a like, but earlier, and less finished, character, so to speak, observable along the far-stretching *ascent* of organised being, and structure,

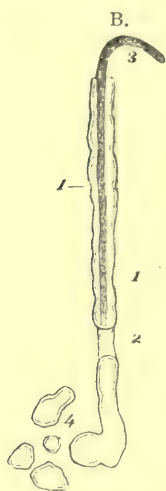


FIG. 122.—B, DIAGRAM TO SHOW THE PARTS OF A MEDULLATED FIBRE.

- 1, 1, *outer or primitive sheath* enclosing the doubly contoured *white substance* or *medullary sheath*; 2, a part where the white substance is interrupted, the outer sheath remaining;
- 3, *axis cylinder* projecting beyond the broken end of the tube; 4, part of the contents of the tube escaped.

but illustrate the steps and stages of the all-pervading, everywhere operative, and moulding, "law of evolution," the beginning, and end, of which, according to both science, and revelation, *are not yet realised*—abundant corroboration of which cryptic expression is afforded, by the study involved in grasping *some very inadequate* meaning of the great fundamental, or root, problems, of matter, force, or energy, time, and space, and the apparent reality, of that "day dream" of the "thinker," that all these great fragments of truth are but the quarry rubble, out of which the structure of the known, and knowable, cosmos, is ultimately to be constructed, and displayed, by us "humans"—even here, and now, we seem approaching a "point of view" from which the two first of these, viz. matter and energy,

seem mutually resolvable. It is possible to conceive, that this fundamental nervine element, the neuroglia, may be liable to mal-development, or deposition, but such an aspect of the subject must be regarded, as almost entirely within the region of the inferential, and the speculative, and, so far, therefore, lacking the possession of facts, histological, physiological, and pathological, it is thus entitled to nothing more than a passing notice; we, however, think, that although the briefest notice, or reference, will here be possible only, we are

warranted, and called upon, to take that notice, and make that reference.

The neuroglial matrix, wherever existent, being the medium of supply for the nutritive wants of the neuronal commonwealth, in both its individual, and collective, aspects, becomes, an anatomical structure of the most supreme moment, in the great functional activities of development, growth, and everyday nutrition, not only of the nervous system proper, but of the whole non-nervous tissues to which the systemic nervous system is distributed, it, therefore, becomes apparent that any congenital, or acquired, mal-development of it, must lead to a departure from the normal physiological condition, of both the nervous, and non-nervous, structures, and, hence, to a departure from the normal functional performance of the involved part, or parts. Holding such views, we infer, that some such circumstances are at work, in the evolution of such a phenomenon, as a congenital *lusus natureæ*, mental, or even physical, and the production of many post-natal freaks, as well as the causation of the many mental, and moral, insanities which are liable to attack the race.

Here we cannot help thinking strongly, that an imperfectly developed, or unstable, neuroglial matrix, must, of necessity, constitute the point of origin of these various phenomena, and that some error in the manner, or matter, or both, of its blood supply, and derived blood plasma, must constitute the first link in the chain, of the morbid evolution in question.

What a vista of possibilities, for weal, or for woe, is thus revealed, or brought within our range of vision, when we recognise, that the data for the full development of this speculation, reach back, it may be, for generations, into the past, concentrate in the immediate parentage, paternal, and maternal, and are ultimately wrought out, and developed, in the present, and future, under the manifold influences of a complicated environment, in the persons of the affected individuals!—heredity, and immediately operative moulding influences, being, conjointly, responsible for the accomplishment of any given result, or results, which may come under our observation, and critical notice.

The obviation of mal-development, and the securing of a normally healthy neuroglial matrix, must be sought for "all along the lines" of growth, nutrition, and active functional life, of that anatomical structure, by the supply of every condition required for the production of healthy metabolism. Of course, these can only be fully, and properly, operative, when a *proper foundation* has been laid, in an absolutely sound, and healthy, parentage, but given that, the results must follow, in every way, in accordance with unexceptional developmental conditions. The maintenance of this normally healthy condition must be sought for, along the same lines, and is securable to the end of life, on these, and these alone, any departure from which, according to universal experience, is followed by, correspondingly abnormal consequences.

The materials for the production of absolutely healthy nerve plasma, having been laid down by the hæmal vasculature, amid the fibro-cellular feltage, constituting the proper connective framework of the neuroglial matrix, it may be asked—are these materials now alive? The question may be answered, in the Scotch fashion, by asking others, to the following effect:—when and by what means does the food, organic, and inorganic, ingested, become alive? True answers to these questions, we acknowledge, in the present state of knowledge on the subjects, it is impossible to give; nevertheless, we feel, all the more, constrained to contribute to their solution, what we can, as flowing out of the unusual problems with which we have been confronted, in our self-imposed exploratory efforts, in fields lying outside of present positive, scientific knowledge, and attainment.

We regard the question of, *when matter is endowed with life* after it has entered the primary, or intestinal circulation, of an organised creature, as being one to which a very guarded reply must be made, inasmuch, as we are aware it can only be founded on, a compound of fact, and somewhat strained induction. The earliest stages in the materio-dynamic experience of the nutritive material are those of mechanical, and chemical, preparation, after which comes physiological admixture, then absorption through organic membrane, circulation into the blood stream, and

aëration, after which, it is distributed, to the various tissues to be nourished, in the form of a, more, or less, vitalised corpuscular compound, to be still further vitalised, by selective absorption, by, and incorporation with, the *living elements* of the tissues. We therefore, content ourselves with the advancement of the statement, that *matter, in the process of vital incorporation, can only be said to be absolutely alive, when the process of vital incorporation with the living, and working, elements of the body, is absolutely complete*; before that, it may be described, as only *partially alive*, while after that, it is *less than absolutely alive*—its pre-, and post-integrative experiences, being the positive, and negative, aspects, of the great process of nutrition. As applied to the growth, and nutrition, of the systemic nervous system, we recognise a somewhat unique, or exceptional, sequence of formative events, in that, as the nutritive pabulum is not extracted, or absorbed, directly, from the blood circulation, and hæmal nutritive media, by the nourished textures, but laid down for neuronal absorption, and incorporation, within the storage areas of the neuroglial structure; where it remains, until it is taken up by the dendritic processes of the countless nerve cells, we may, therefore, infer, that the amorphous, and the, more, or less, developed, vitalised, and organised, matter, of the neuroglia, is absorbed by the nerve cells, in a condition of more, or less, active, life, or vital dynamic potentiality, and that it is vitally preserved, conserved, or kept in readiness, for nervine absorption, and incorporation.

In all this departure, from the ordinary mode of physiological provision of nutritive material, in the processes of growth, and repair, of neuro-cellular, tissue, we perceive a means of nervine supply, which we may describe as “balanced,” whereby, constancy, and immediate availability, are secured, independently of the ordinary, and somewhat fluctuating, hæmal, nutritional resources. Thus, we see provided, amid the meshes of the neuroglial connective textures, contained within the brain, cord, and ganglia, of the systemic, and the sympathetic, nervous systems, a vast quantity, or a storage, of the raw material of nerve pabulum or prospective nerve plasma, ready for conversion into actual neuronal plasma, by a specific

process of neuronal ingestion, intra-cellular molecular disposition of the ingested materials, and imbibition by the nuclei, and nucleoli, of their respective nutritional elements, by their respective peripheral, and containing, membranes, or outer coverings. These processes of nerve, protoplasmic ingestion, and nutrition, result, and culminate in constant plasmic streams issuing from the neurons, and circulating along their axons, in the form of the medullary, and axis-cylinder, substances, and the provision of what nutritive material is necessary for the insulated, and independent, needs of the nucleolar bodies.

Respecting this ever-ready supply of neuronal plasma, we would observe, that, even the most fluctuating demands, on the part of the systemic nervature, can be, at once, and fully met, by a constant supply, without the necessity of appeals to the supplementary offices of the blood circulation, thus, securing a self-sustaining power, both material, and dynamic, which places the maintenance of life, on a sound, and secure, basis. Moreover, we are disposed to think, that the natural, and rhythmic, occurrence, of sleep, and disuse of the higher systemic nerve centres, explains, and has its explanation in, lapse of "dynamic release," or periodic "dynamic conservancy," and "renewal," or "redistribution," of nerve energy.

EXTRACT XXVII. A.

ON THE CELL, IN ITS GENERAL BEARINGS ON THE EVOLUTION OF LIVING FORMS.

THAT the cell, individually, and collectively, constitutes the organic foundation of all living forms, may now be, and, we may safely say, is admitted as axiomatic, and that it affords not only, a theoretical, but a working, scaffolding, on which we can, in safety, perform the duties of organic science builders, with the maximum of success, and the minimum of failure, has now been abundantly proved. The cell individually, or the individual cell organism, has performed, and continues to perform, the pioneer work of organic life, claiming, from the inorganic matter of the earth's crust, the materials, out of which it elaborates, by vital energy, its distinctive protoplasm, clothing itself with an outer, and differentiating, covering of that protoplasm, which ensures the maintenance of its individuality, and the power of perpetuating itself, by division, into still more individual cells, which, by like divisional processes, continue the work, *ad infinitum*,—an organic fact, which is now being utilised for purposes of the greatest hygienic importance, as witness, the adoption of bacterial agency, in the analytical treatment, and hygienic disposal, of sewage. The cell unit, as witness the amœba, while thus living, acts by, and for, itself, and is characterised by individuality of action, and merely accidental community of purpose, and represents the primary form of cell life, *i.e.* it begins, and ends, in self, so far as it individually is concerned, disappearing absolutely when it has performed the functional rôle destined for it, but

leaving behind it the legacy of its organic remains to its descendants. It is entirely otherwise with the cell, whose life is passed in collective (Figs. 123, 124, 125, 126) existence, and where it constitutes, a definite unit, in a community of cells, held together by complex, though definite, vital arrangements, for the purpose of allowing, or securing, the existence of a definite living organic form, vegetable, or animal, whose individual life, in each instance, is determined in length, and character, by its position, as to fixity, and mobility, in the organic form, or community, and by the nature of its individual

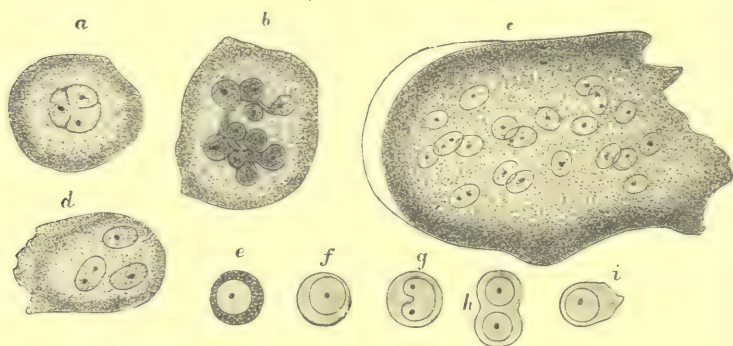


FIG. 123.—MULTINUCLEATED CELLS FROM THE MARROW. Highly magnified. (E. A. S.)

a, a large cell the nucleus of which appears to be partly divided into three by constrictions; *b*, a cell the enlarged nucleus of which shows an appearance of being constricted into a number of smaller nuclei; *c*, a so-called giant-cell with many nuclei; *d*, a smaller cell with three nuclei; *e*—*i*, other cells of the marrow.

function in the economy of that organism, or cell community. The individual cell, which pursues a solitary existence, and whose “end and aim” is self, typifies, also, the nature, and purpose, of the individual organism, or community of cells, whose “end and aim” is also self, and whose existence is maintained, in most cases, by its preying on its unicellular relatives, and more defenceless multicellular neighbours, and which constitutes the beginning of that long chain of organic forms, which, commencing in solitary cell life, ends in communal existence, in the person of man himself, but whether it will really end with man, our far-distant successors must be left to determine.

Cell life is enjoyed, in common, by the unicellular organism, if we may call it so, the multicellular creature, vegetable, and animal, the limbed, and voluntarily moving, being, and the erect, and thinking, man, himself, but how unlike in character, and degree, is that life enjoyed ! Life, as thus enjoyed, is dependent on the existence of a nervous system, which initiates, controls, and maintains, all vital processes, evolving, and distributing, vital energy, securing the persistence of living forms, and evolving

FIG. 124.

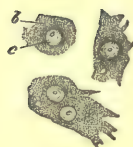


FIG. 124.—THREE CELLS FROM EARLY EMBRYO OF THE CAT. Highly magnified. (E. A. S.)

b, protoplasm ; *c*, nucleus with nucleolus. The lowermost cell has two nuclei.

FIG. 125.

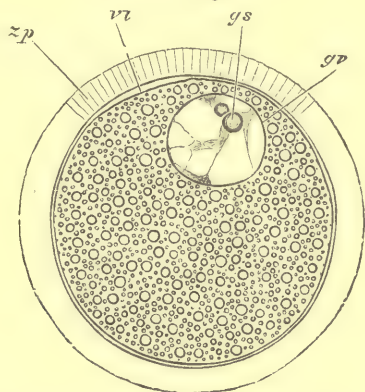


FIG. 125.—OVUM OF THE CAT. Highly magnified. Semi-diagrammatic. (E. A. S.)

zp, zona pellucida ; *vt*, vitellus ; *gv*, germinal vesicle ; *gs*, germinal spot.

higher, and higher, types, which culminate in the appearance of rational beings, and the introduction into the guidance of the evolutionary process, of the high, intellectual, and moral attributes which make for the elimination of pain, and suffering, and result in the substitution of the reign of "faith, hope, and charity." The nervous system, in the unicellular organism, pervades the protoplasm of that cell, determines the character of its life-work, and is limited within its containing wall. The nervous system, in the multicellular creature, however, undergoes a great modification, and becomes, for the first time in

developmental sequence, a real nervous system, but entirely of the sympathetic variety, in virtue of each cell of the community, into which the primal cell, has divided, and subdivided, being held together, and innervated, by a process, or processes, uniting each unit, or cell, and directing their individual work, for communal purposes. In the limbed, and voluntarily moving, animal, a third form of nervous system is evolved from the second, as

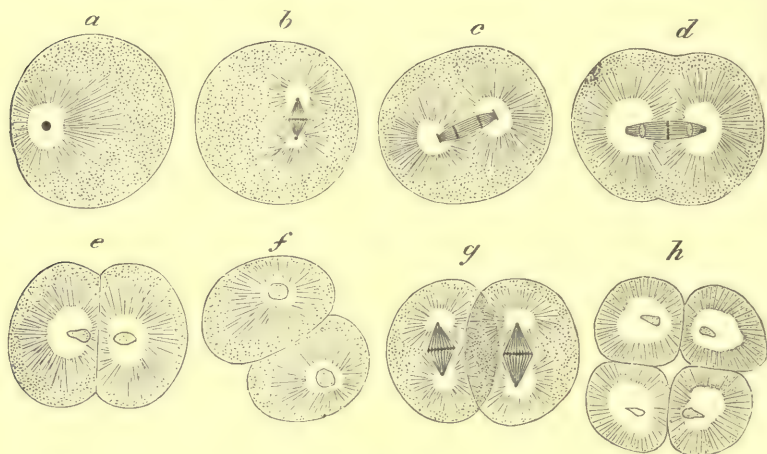


FIG. 126.—STAGES IN THE DIVISION OF THE OVUM OR EGG-CELL OF A WORM. (Strasburger.)

a, resting state; *b*, nucleus transformed into a spindle-shaped system of fibres, which are provided with thickenings at the equator of the spindle; *c*, separation of equatorial thickenings into two parts which gradually travel towards the poles of the spindle and there become transformed into new (daughter) nuclei, whilst the protoplasm at the same time also separates into two parts (*d, e, f*); *g*, repetition of the division process, formation of spindles in daughter cells; *h*, result of the division of these. (The nuclear filaments are here probably only represented by the thickenings at the equator of the spindle-shaped system, which is mainly formed by fine straight filaments, which stain far less with hæmatoxylin than the others, and on account probably of their less distinctness and want of colouration are not seen.)

the second is from the first, by which its many multi-cellular organs, and parts, are made to subserve the, common purposes, and co-ordinated functional work, of a complex organism—this nervous system is called the systemic nervous system, and is under voluntary control. Arising out of, and evolved from, this systemic nervous system, is a great central nerve organism, the brain (Fig. 127), which, in the human species, reaches such a magnitude, and complexity of structure, and relationship

with all parts innervated by that system, that it dominates the, working, and destiny, of every member of that species, in a way absolutely unique, in the whole extent of natural history.

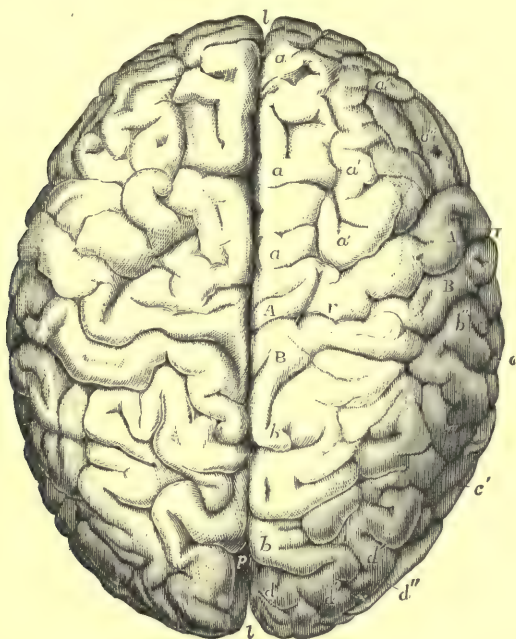


FIG. 127.—UPPER SURFACE OF THE BRAIN SHOWING THE CONVOLUTIONS.
 $\frac{1}{2}$ (From R. Wagner.)

This view was taken from the brain of Professor C. F. Gauss, the mathematician, who died in 1854, aged 78. It is selected as an example of a well-formed brain of the average size with fully developed convolutions.

a, a, a, superior or first frontal convolution; *a', a', a'*, second or middle frontal; *a''*, third or inferior frontal; *A, A*, ascending frontal convolution; *B, B*, ascending parietal convolution; *b*, superior parietal lobule; *b''*, inferior parietal lobule; *c*, first or upper temporo-sphenoidal convolution; *d*, first or upper occipital convolution; *d'*, second or middle; *d''*, third or lower; *l, l*, the longitudinal fissure; *r*, the sulcus of Rolando; *p*, the external parieto-occipital fissure (which appears, in consequence of the position of the brain, nearer to the posterior extremity than it really is).

The cell, therefore, may be regarded as the “all in all,” in the process of the evolution of living forms, as they are to be observed throughout the entire field of natural history, but its initiation, or start in life, involves a *creative act*, so momentous, and unique, as to place it entirely beyond the power of the spontaneous action of any form of known energy, on any form, or combination, of known matter, or substance, to accomplish, hence we must regard

it, as altogether transcendental, and inexplicable by science, but an absolute certainty nevertheless, and, so far as we can discover, altogether attributable to a "*Great First Cause*"—in other words, to *The Power*, beyond nature, and evolution, of whose existence, all organisms, and phenomena, are but the outward, and visible, symbols, and the unmistakable earnest to us, that an Infinite Intelligence, and Power, is working "behind the scenes," whose personality is *quite visible* to the "eye of faith," and as undeniably existent, as the symbols themselves, or the thinking "ego." Moreover, who, can observe, and realise, the beauty, and order, the precision of working, and the momentous results flowing from, *the creative act*, but must acknowledge that absolute perfection of design, and infinite power, combined, must have dictated its details, and superintended its accomplishment? Nature, evolution, chance, accident, *et hoc genus omne*, what are they, when considered in this light? Are they not, but words and names, and words and names, only, doubtless most expressive, but, here, unintelligent as inert matter, and powerless as the non-existent? In human intercourse, do we not often hear the words repeated, in extenuation of human helplessness, or human listlessness, "you must take the will for the deed"? In somewhat like manner, and from kindred causes, do we not at times, in the most unexpected quarters, also see a belief entertained, and even expressed, *in the "made," but not in the "maker"*!

EXTRACT XXVII. B.

ON THE CELL, IN SOME OF ITS INTRINSIC, INDIVIDUAL, AND COMMUNAL, ASPECTS, AND IN THE GENESIS OF THE NERVOUS SYSTEM.

To the cell is now assigned a functional rôle, embracing the initiation, and evolution, of all vital phenomena, whether nutritive, developmental, or perpetuative. From the origin of the fecundated ovum, and parent cell body, until the termination of the communal cell life of the individual unally, or sympathetically, innervated organism to which it gives rise, one unbroken cell developmental process prevails, which only terminates by death, and dissolution; the life history of the organism is, therefore, made up of a succession of cell growth, and division, of re-cell growth, and re-division, in unbroken continuity from the date of origin of the parent cell, to that of the last generation of its successive cells, when failure of vital energy, to maintain the required vital material conditions of the organism's cell community, ensues.

The essential condition, or principle, underlying, and determining *that every cell is preceded by a parent cell, except the systemic nerve cell*, and that every cell which does not perpetuate, or reproduce itself, cannot, in consequence, exist in perpetuity, but hence must perish, or terminate its line of descent, when it has lived its own individual life.

The cell that manages, by gemmation, or kariokinesis, to perpetuate itself, ensures the continuation of itself, in the new cell genesis, with all its attributes, modified, and fitted, by altering environment, to secure its

continuance indefinitely, or so long as the conditions of such cell life are maintained. It, therefore, goes without saying, that every such cell possesses life, with the implied power of developing, and perpetuating, itself (see Fig. 118), and that this possession secures, along favouring lines, and under suitable environment, a continuous succession of cell units, and communal cell organisms. This must be held as applying to cells as individuals, and communities, innervated by the sympathetic nervous system, and not to cells belonging to the systemic neuronal units, and communities, which latter, do not *repeat* themselves, or become subservient, to the law of kariokinesis—a cellular condition, marking a new, and absolutely unique, distinction, in the rôle of cell life, within the higher animal life organisms, or those whose innervation is dual. The cell life, or energy, is *sui generis*, and cannot be replaced by, or continued as, any other known form, or forms, of energy, and, hence, must be regarded, as synonymous with that form of energy known as, vital. Each cell is vitalised, and, so to speak, innervated, *minus* a developed nervous system, by this energy, along, it may be, molecular lines, and in virtue of the existence, or provision, in the cell contents, of circulatory facilities, or molecular pathways, for the play of vital energy, or force; each cell, moreover, by the exercise of its inherent formative powers, or impulses, acting through, or by, the agency, of its vital energy, on its protoplasmic elements, perpetuates itself by, gemination, mitosis, or kariokinesis, transmitting to its succeeding, or resultant, cell, or cells, a sufficient moiety, or portion, of itself, with all the vital, characteristics, and qualities, to fit it, or them, to grow, and, in turn, to repeat the process of perpetuative growth. The vital processes, including the evolution, and circulation, of vital energy, involved in the primitive form of cell growth, and perpetuation, may be described as *diffuse*, or only *molecularly stranded*, and *determined*, and is characteristic of only the earliest stage of growth of the human fecundated ovum, the succeeding stage, or where cell fission, and increase of cell bodies, has begun, necessitating the provision of the rudiments of nervous arrangement,

or means whereby the proliferating, and accumulating, cell bodies, can be maintained in organic union, sufficiently binding, or intimate, for the accomplishment of communal, or organic, purposes. This advancing stage may be described as, one of *agglutination*, by cellular contiguity, and continuity, sufficiently intimate for purposes of concerted vital action, but devoid of a *fully elaborated* vital energy conveying machinery, such as is provided in the later stages of embryonic development.

The yet more advanced stage of embryonic development, which consists in the arrangement, of the now rapidly increasing primitive cells, into layers of different, character, and position, where the blastoderm is divided into the ectoderm, the mesoderm, and the hypoderm, necessitates the laying down of the foundation of the future nervine organisation, by super-position, interposition, inter-penetration, and co-ordination, of structure, for the production, conservation, and circulation, of energy, and non-plastic, and colloidal, nutritive materials, which now becomes, more and more, required, by the provision of a system of intercellular nervine circulation, of vital energy and plasma; this stage coincides with the provision of a system of inter-cellular communicating processes, or "linking up" cellular structural arrangements, which becomes the basis of the future sympathetic nervous system. All these phases, or stages, in the evolution of the details of cellular development, and perpetuation, with the involved problems of vital energy production, and distribution, and plasma circulation, belong to, and are concerned alike in, the origin, and succession, both of vegetable, and animal, forms,—a line of demarcation becoming noticeable, at the next stage, or where the conditions of life become more complex, when, besides the sympathetic nervous system, which is still utilised to conduct the organic work, or pure vitalism, of the organism, a systemic nervous system is added, or evolved, in the more advanced, or highly organised, animal forms, in order to fit them for taking part voluntarily, and intelligently, in the many processes embraced in the "battle of life," on the movable, and constantly altering, stage, of animal contention, and "struggle for existence."

This *line of demarcation*, marks the most important departure, from the hitherto existent cellulo-nervine, and sympathetically fibro-nervine, manners, of vitalisation, and innervation, thus far common both to animal, and vegetable, organisms, and forms the foundation, on which the evolution of the systemic nervous system, in all its parts, and varieties, and in all its degrees of simplicity, and complexity, from the insect to man himself, is wrought out, and perfected; it, moreover, forms the stepping stone, to that high organic platform, on which have been wrought out, and evolved, the higher physiological, or intellectual, qualities, and attainments, and the highest of all human characteristics, the moral qualities, with the implantation of that craving, after the gratification, if not entire satisfaction, of the uniquely human conception of immortality.

Life, and all that it primarily means, on the earlier, or rudimentary, side, of this somewhat *arbitrary line of demarcation* in neuro-genesis, is first, confined within intra-cellular limits, and second, is limited to inter-cellular proportions, in addition to the intra-cellular, when cells have sufficiently increased to require organisation; in the cellulo-genetic process. Segmentation of the parent cell is regarded as due to nuclear selection, and disposition, of the cell protoplasm, whereby its vitalised, and innervated, molecular constituents, are segmented, and prepared for independent existence, with every attribute of the original cell reproduced, and capable of repeating the process. The parent cell, in the process of sympathetic neuro-genesis, may be regarded, as maintaining a, more or less, prolonged, or temporary, structural connection, with its segmented, and differentiated, progeny, in all varieties of organised cell groups, or textures, in virtue of a, more or less, sustained intercellular continuity, or quasi-nervine connective tissue. The highest stage of this type of neuro-genesis, is reached, in the complex organisms of the highest types of plant life, in the non-systemic nervous system possessed members of the animal kingdom, and in the sympathetic nervous system controlled textures of the systemic nervous system possessed animal world.

Neuro-genesis, and cell proliferation, may, therefore, be regarded as equal, in their rate of evolutionary progress, and textural limits, and as representing but two aspects of the same organic process; in other words, neuro-genesis, and cell proliferation, are necessarily identical in their incidence, as vital phenomena, in the evolution of life forms generally, from inorganic matter, and in their genetic, and developmental, operations, in the evolution of individual organisms, vegetable, and animal.

The cell, as a living unit, possesses within itself its own nervine, or vital, apparatus, or quasi-nervous system, differentiated, and separate, from its environment; the cell group, or segmented cell, on the contrary, and in addition, while possessed of such a system in each of its divisions, maintains a, more or less, permanent nervine connection, between its several cells, by virtue of a, more or less, intimate structural connection, between parent, and derived, cells, whereby is made possible the operations of vital, and formative, energy, in the processes of organisation, growth, and the differentiation of living forms—therefore, the cell lives, by virtue of its containing a quasi-nervous system, this being inseparable from, and mutually essential for its life, and vital activity, and the cell group, in like manner, lives in virtue of the same individual cell conditions, plus the existence of an inter-cellular nervine connective system, secured by the survival of structural segmented continuity, or contiguity, and finally, by the elaboration of what is equivalent to, a sympathetic nervous system. It is, thus, apparent, that the parent cell, and the descended cell, cannot, and do not, exist, or live, apart from a nervous system, we are, consequently, compelled to recognise the operation of a great *law*, which *combines the working* of all vital processes, by the nervinely inspired, and possessed, organic cell. The cell, individual and communal, and the nervous system, are “one and the same” thing, *i.e.* they constitute the material, and dynamic, aspects, of the one great problem, *viz.* life.

We must, therefore, be prepared to acknowledge further, if these views be true, that all cells, by whatever name known, are *in reality* also, *one, and the same*, in

nature, and origin, and have only been differentiated by the incidence of environment, and the functional necessities, flowing from the exigencies of varied organic evolution. All organic life, including the systemic nervous system possessed life, it will, thus, be obvious, is embraced within the operation of the law, and has been, and must be, evolved on lines determined by its all-pervading, formative, and moulding influence, in transforming the inorganic "dust of the earth," into the teeming millions of living organisms, known to present-day science, besides the multitudes, which have haunted the solitudes, and peopled the busy places, of the ancient world.

The succeeding stages of neuro-genesis concern, the appearance of a distinct, and great, advancement, in its elaboration, and growing complexity, as the type of organism mounts "the scale of being," and shows the introduction, into the conduct of an absolutely automatically working mechanism, of a principle of conscious, and voluntary, control, of the most profound, and far-reaching, character, and influence, as affecting the individual organism, and the destiny of living things, and as shaping the course of future evolution, in its bearing on the advent of the human species, and the progress of civilisation.

The neuro-genetic stages, thus referred to, consist, in a word, of the various phases of unicellular, or molecular, innervation; communo-cellular nervine association; sympathetically innervated, and controlled, organisation; and combined systemic cellulo-sympathetic organism.

EXTRACT XXVIII. A.

ON THE GROWTH OF THE SYSTEMIC NERVE CELL, AND WHAT FOLLOWS. WITH NEURO-PSYCHIC GENESIS.

ON studying the subject of Eczema, and allied affections, we were led to infer, that the epidermic scales, and the cells from which they were evolved, must, to some extent, have been composed of the "cast off" material, or apparel, of the afferent peripheral terminal nerve (Fig. 128) structures, and that they, thus, represent an excretory product; in other words, the continuous "shedding" of the skin must represent, to some, indeed the larger, extent, the detachment, from the outer surface of the organism, of effete material, derived from the growth outwards to the skin of the neuroglial matter, through the nerve cell, as the medullary, and nuclear, or axis cylinder, protoplasm, of the various neurons, along the axonal nerve fibres, until it reaches the various peripheral nerve endings, throughout the entire cutaneous envelope. *A similar idea* had struck us before, in connection with the study of rheumatism, and the manner of termination of the efferent or motor nerve fibrils in the substance of the muscles.

We would add, besides, that the secretory rôle, which we here have assigned to the nerve cell, in all its varieties, necessitates the existence, or provision, of an excretory mechanism, equal to the discharge of the secreted material, and that, in looking, and searching, for such a mechanism, we have followed the axonal processes of these cells, to their synapses, their ganglionic cell interruptions, and

finally to their peripheral terminal extensions, in the various textures, and organs, of the body, and there we have discovered, to our own satisfaction, in the multitudinous nerve terminal arrangements, the required mechanism, and means, of securing the excretion, or

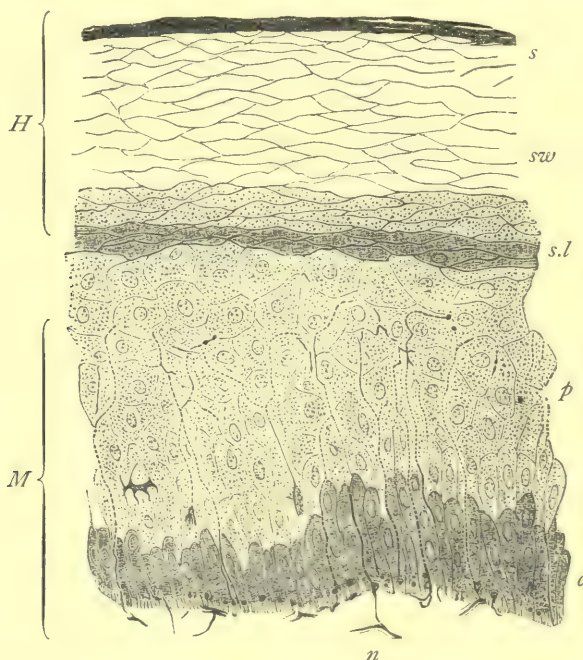


FIG. 128.—SECTION OF EPIDERMIS FROM THE HUMAN HAND. Highly magnified. (Ranvier.)

H, horny layer, consisting of *s*, superficial horny scales; *sw*, swollen-out horny cells; *s.l*, stratum lucidum; *M*, rete mucosum or Malpighian layer, consisting of *p*, prickle-cells, several rows deep; and *c*, elongated cells forming a single stratum lucidum, are not shown, *n*, part of a plexus of nerve-fibres in the superficial layer of the cutis vera. From this plexus, fine varicose nerve-fibrils may be traced passing up between the cells of the Malpighian layer.

elimination, of the used-up neuronal, or nerve cell, secretion. This process is effected, in varying, but kindred manner, alike on the surface of the skin, of the mucous, and serous, linings, of the various tubes, or vessels, glands, cavities, and viscera, and amid the muscular elements of the body, wherever the systemic nervous system penetrates,—in short, wherever a nerve fibril terminates, whether systemic, or sympathetic, sensory, or motor.

The materials excreted, may be immediately, and finally, thrown off, or may still be utilised for purposes of, protection, growth, lubrication, etc., ere they are allowed to be finally disposed of, or shed; thus, the epidermis, with its appendages, may be largely regarded, as the latest, or final, organic result of the peripheral, or sensory, nerve excretory process, while the muscular fibre structures may likewise be regarded, to some extent, but to some extent only—the exceptions being interstitial nerve products—as the final stage of motor nerve cell excretion, or elimination—the sympathetico-systemic system, also, having its excretory contents disposed of, used up, or spent, in aiding in the execution of the various duties to which it becomes subservient, in the economy of the involuntary operations of the muscular system. This process of excretion, or, what may be regarded as, the final stage of, or in, the nerve developmental evolution of the nerve cell, and nuclear products, takes place, in, and on, the free surfaces of the skin of the body generally, where the epidermal scales are shed, as Milton says, “Thick as autumnal leaves that strew the brooks in Vallombrosa,” in, and on, the free surface of the mucous, and serous, membranes, and linings of the free surfaces within the body generally, and within the sarco-lemmar coverings of the muscular fibres, striped, and unstriped, wherever present, throughout the, length, and breadth, of the systemically, and sympathetico-systemically, innervated organism. Thus, we perceive, that a far-reaching vista of nerve activity, within the sphere of the fundamental vital, or physiological, processes of, assimilation, nutrition, disintegration, and excretion, is opened up for investigation, and a prospect of important practical results presented.

We shall now proceed slightly to elaborate the foregoing views, in order to make their meaning more plain, and to explain, in somewhat greater detail, what takes place, between the ending of the blood circulation within the neuroglial texture, the beginning of the formative, or organic, processes, through which the materials left by it pass, within that texture, and the methods by which, the residual materials, are finally disposed of.

The structure of the nervous system, as already explained, is made up of a series of cells, and fibres, or neurons (see Fig. 118), the axons of which latter, in turn, are composed of a series of dual plastic rods, one cylindrical, and hollow, and one solid, the latter occupying the hollow in the former, encircled by their respective tubules of neurokeratin; the cells are laid down in, and supported by, a matrix of neuroglia, in which they are rooted by their dendritic (see Fig. 118) processes, through which they extract their nourishment. This may be regarded, as the primitive, and foundation, structural condition of the systemic nervous system in all its parts—alike of the cerebrum, the cerebellum, the spinal cord, and the ganglionic enlargements of the systemic nerves, as well as the sympathetico-systemic system.

The cells thus rooted, *secrete*—and contrary to the received teaching on the subject, we claim that, they also, *do, and must, excrete*—indeed, it would be nothing short, of “a contradiction in terms,” and a physical impossibility, that it *could be otherwise*. But, excrete what? it may be asked. We answer, that they, *necessarily, must, and cannot do otherwise than*, excrete, the substances known, as the medullary, or “white substance of Schwann,” and the axis cylinder substance. They, thus, secrete, or provide, the nutritive materials required for the maintenance of their contained organisms, the nuclei, and nucleoli, the former of which, the nuclei, in like manner, secrete from the cell protoplasm, and excrete the substance of the axis cylinder, while the nucleoli *secrete* from the nuclear protoplasm, what they require, to enable them to continue their, individual, and independent, existence, and active functional rôle, and which must, of necessity, and in this case, contrary to the rule, *excrete*, or shed, their effete materials into the, as yet uncontaminated, or only self-contaminated, nuclear contents, and axis-cylinder protoplasm—these so-called effete materials, it may be, becoming the intra-axonal substance, or molecular strand, or channel, for the conveyance, or passage, of nerve energy, into, or out of, the cell.

These excretory substances, do not become fully, or finally, excreted, or disposed of, until they have made a

more, or less, circuitous intra-fibral journey, and performed a prolonged functional work, of the very highest importance, and of the widest textural range, or until they reach the limits of the peripheral nerve terminations, wherever situated, sensory, and motor, systemic, and sympathetic, alike, where, their functional being completed, they are finally liberated, by the exfoliating epidermic, epithelial, and endothelial, cells, and scales, and the shedding skin appendages, as well as by the musculature in which the motor fibres terminate; besides, to some extent, we would infer, in a, more or less, amorphous form, by the sweat glands, and sebaceous follicles, of the skin, and the various excretory agencies developed within the texture of the various mucous, and serous, membranes, of the body. It thus becomes apparent, that secretions, elaborated by the nerve cells, their nuclei, and nucleoli, from the surrounding neuroglial pabulum, have to traverse the entire extent of the axonal processes of the cells, *i.e.* the nerve fibres, from their origin in the cells from which they respectively spring, to their terminations in the various nerve terminal textures, or arborisations. This constitutes the inner division of, what we may term, the great dual systemic nerve circulation, or the combined, or duplex, nervine circulations—the other being the cerebro-spinal lymph circulation.

The “*growth*” of the systemic nervous system may, therefore, be said to *begin* as, or to consist of, a *secretion* from the neuroglial matrix, to *end* as, an *excretion*, on the various free surfaces, and enclosed spaces, in which the nerve terminals end, and to *consist* of the stages of, *assimilation* by the cells, their nuclei, and nucleoli, of *circulation*, by, and through, the neurokeratinous tubes, or vessels, known as the containing membranes, of the medullary, or white substance of Schwann, and the axis-cylinder, respectively, of *incorporation* with, or in, the epidermic, epithelial, and endothelial, coverings, and linings, respectively, as regards the sensory, and sympathetic, distribution, and of the, more, or less, *permanent disposal*, in the sarcous elements of the muscles, as regards the motor distribution, of the nerve fibre terminals, and of the final, *exfoliation*, *shedding*, or *excretion*, which ensues,

as the closing stage, of a prolonged series of formative, or integrative, circulatory, and disintegrative, changes. Thus, the nervous system, the most vital of the many systems of which the corporeal organic whole is made up, may be traced from a primary involution, embryonically, of the epiblast, to a terminal, or final, evolution, or exfoliation, in the mature stages of development, of the same epiblast, after its prolonged passage through the intricacies of the meso- and hypo-blastic areas, as an unbroken process of growth, and finally of decay—representing, what may be denominated, the concluding stage of the long process of developmental, or organic, evolution.

Moreover, the various stages, of this long developmental process, represent, a balanced, and ordered, succession of *evolutionary events*, the culminating, and crowning, example, of which is typified, and represented, by that under discussion—the systemic nervous system, which constitutes the “end and aim” of the great organic “sequence of events,” exhibited in the life-history of all the higher animal bodies. So long, as the integrity of the nervous system, including here the sympathetic nervous system, of an animal body, is maintained in unbroken continuity, so long will the life of that body be maintained, so soon, however, as its maintenance in that condition becomes impossible, will the death of that particular body, in whole, or in part, ensue, according to the general, or local, incidence, of the pathological conditions by which it is invaded.

The entire nervous system, judging from the oneness of its functional work, consisting of, trophic, motor, sensory, and intellectual, activities, must, of necessity, be one, in histological, and anatomical, continuity, or, at least, its component parts, must be in material contiguity, so complete, and intimate, as to permit of functional oneness, and to ensure that it developmentally projects, or interjects, itself, into material, and functional, relationship, with every organ, and texture, of the body, thereby, dominating, and controlling, the functional, and organic output, in regard to work, and securing its physiologically measured maintenance, in whole, and in part.

The nervous system, thus, becomes the centre, and potential, or dynamic, mainspring, of the life-work, of all the highly organised examples of animal life, besides being, itself, the peculiar, and cryptic, material region, in which repose the inscrutable mysteries of life, and intelligence, with all their attendant attributes, and entities, material, and immaterial.

Though composed of innumerable quasi-independent centres, and areas, but being, one, and indivisible, anatomically, and histologically, through the complete organic continuity of its component neurons, it must inevitably follow, that its functional work, or activity, in part, and in whole, must be conformable to, and controllable for, both local, and general, purposes—each neuron, thus, representing a quasi-independent organism, as well as, being an individual member of the great nerve community, or commonwealth, so to speak, and extracting its support from the common neuroglial soil in which the entire nervous system is rooted, and from which it grows by dendritic absorption. From this common neuroglial soil, cerebral, cerebellar, spinal, and ganglionic, all systemic, and sympathetico-systemic, nerve cells, alike, derive their nourishment, converting it into the necessary protoplasm for supplying the nutritional wants of their respective nuclei, and nucleoli, with their axonal continuations. The cell protoplasm, or such part of it as is utilised in the support of the nucleus, and nucleolus, passes, or grows, along the axons, or axonal processes, in the form of the medullary, or “white substance of Schwann,” and the axis cylinder substance, and is finally shed, by the various nerve terminals throughout the entire nervous system, in the form of, more, or less, plastic, and organisable pulp, which ends, as a material addition to the substance of the epidermic, epithelial, and sarcous, elements, wherever it may happen to be shed, or accordingly as it may be finally disposed of preparatory to removal, as effete, and worn-out material, with the exception of the addition made, by the motor “terminal plates,” to the discs, or cells, of the muscle fibres, where, it is conceivable, it may perform further important, material, and functional, duties, in maintaining the latent

potentiality, and contractility, of these muscle fibres, by becoming, in fact, a nutritive pabulum, for their growth, and maintenance. Moreover, it seems impossible to assume that the very large amount of white, or medullary, and axis cylinder, substances, which must be discharged from the motor nerve "end plates," or terminals, can be otherwise disposed of, than in supplying the nutritive material necessary for the wants of the great muscular system, and, so, of keeping up that intimate, material, and functional, or materio-dynamic, union, of nerve, and muscle, so essential for the proper discharge of the complex duties, of meeting the requirements of volition, as well as, those of conveying involuntary impulses for automatic movements, single, and co-ordinated, alike—and that, therefore, this matter, or substance, does not become effete, until it has discharged, or contributed to discharge, the function of muscular contraction, with its accompanying waste, when, we may take it that it is discharged, or conveyed, into the systemic lymphatic system, *via* the muscle tendons, periosteal textures, and associated bone matrix, and medulla, and so into the blood stream, for final disposal—in contrast to the final elimination of the, medullary, and axis-cylinder, substances, characterising the sensory nerve terminals.

In still further detail we would remark that the nucleus, in like manner with its parent cell, forms or secretes the protoplasm of its body, that protoplasm being retained in position by its encircling or containing wall, from which it in turn passes or grows along, or as the axis cylinder separated from the medullary or white substance by a continuation or prolongation of the neurokeratinous nuclear envelope until it arrives at the confines of the individual fibres, where it undergoes the process of final disposal or elimination by the various forms of nerve terminal arrangements, as effete, but not yet quite functionally exhausted material. The organised materials composing the medullary substance and the axis cylinder substance alike circulate from the cells and nuclei respectively to the boundaries of the nervous system—on the skin and membranes, in the substance of the parenchymatous textures and within the sarcolemmar coverings of the muscular fibres,

and being plastic or fluid enough to circulate, they are constantly liable to suffer from stases and disturbances of their continuity within the lumina of the tubes or containing walls along which they are moving or circulating, from "a thousand and one" causes. We would expect, therefore, to find that their onward and outward movement is safeguarded and secured against the possibility of destructive regurgitation, and we think we have discerned the existence of the required means in the cellular and fibril arrangements and re-arrangements within the brain cord and nerves, the last mentioned and the nerves being specially protected by the introduction and continuous reproduction, it may be, of the histological textures known as the "nodes of Ranvier," which have already been described, and which, we claim, allow of an efferent, but prevent an afferent movement of the intra-neuro-fibril contents.

The nutrition of the textures in question, viz. the medullary and axis cylinder, with their enclosing or containing walls, may be accepted as taking place, from the matrix of the neuroglia, by the exercise of the inherent selective and assimilative, or vital, powers, or properties of the cell dendrons, determined and sustained by their contained nucleoli, the presence of which latter is to be regarded as essential to nerve cell existence.

We are warranted here, we think, in concluding that nowhere does communication exist between the nutritive materials, directly or immediately, which pass from the hæmal to the neural structures, save by the intervention or carrying agency, so to speak, of the neuroglial textures—nutrition of the neurons being universally due to, or effected by, the selective influence exercised on the passing blood streams by the neuroglial texture, through which the required pabulum is supplied to the widely deployed and constantly foraging dendrons of the waiting and hungry cells.

Thus we may regard the systemic nervous system as a system within a system, or rather within a system of systems, and we may look upon these systems as being only "the means to the end" of supporting and ministering to the wants of a contained central material organism, capable of being energised and wrought upon by an immaterial

agency, or directing power, which the materialist and spiritualist alike are compelled to name and to regard as *the ego*—the living principle not detectable by any scientific processes, but representing, or remaining, the irreducible residuum of the organised body after the dissolution of all its material parts, the then nature and whereabouts of which, and of what still exists, constituting the unfathomable mystery so warmly discussed by divine and scientist all along the ages, and affording a theme for the consideration of the transcendentalist, at once hoary with age and verdant with eternal youth.

These evolutionary arrangements originate primarily in the earliest embryonic histological disposals of the epiblastic elements, by means of which the meso- and hypo-blastic areas are inter-penetrated, innervated, and traversed, until their boundaries are reached, when they culminate and conclude by assisting to form the external coverings, the internal linings, and the muscular textures of the entire body.

In concluding this somewhat inconsequent study, we would remark that inside all these complex envelopes and investitures of cell wall, cell protoplasm, nuclear wall and nuclear protoplasm, and nucleolar wall, is disposed the deepest and smallest of all corporeal organised particles, the nucleolus, an apparently independent entity texturally, but functionally, we think, most intimately related with its environment, and apparently connected with the most important duties of, receiving, producing, conserving, disposing, and transmitting, nerve impulse, and energy, a tiny material organism, responsive to the most delicate molecular disturbance, conserving unexhausted nerve energy, originating, and transmitting, nerve impulse—ranging from the most delicate, or “pale cast” of, thought, to the most explosive, and disruptive, motor “convulsions, in action individually gentle, collectively, cyclonic. Who will portray, or is it possible even to discover, by means of the employment of the most transcendental scientific experimental process, the subtle scheme, by which these wonders are wrought? May it not be, that a radium-like molecular strand of nucleolar substance, or protoplasmic material, projects itself along the innermost

core of each axis-cylinder, affording a pathway, along which nervine messages are carried to and fro, and through which the presiding *ego* acts, and is reacted upon, by the *non-ego*? Here, however, all is mystery, in the solution of which, observation, and experiment, seem alike helpless, we, therefore, bid adieu to the alluring subject, hoping to take it up again, when an opportunity for its *metaphysical study* shall present itself.

EXTRACT XXVIII. B.

ON THE PSYCHIC, OR MENTAL, BRAIN CELLS.

SINCE writing the foregoing, we have continued to pursue enquiries into the, histology and histogenesis, of that neuronal area, in which the phenomena of mind proper, or intellect, and cogitation, are produced, or evolved, and have become possessed of the thought, and belief, that the two aspects, or areas, of systemic innervation, viz. the sensory, and motor, are texturally joined, and functionally united, for purposes of systemic administration, and co-ordination, by a central area of, *mental*, or *quasi-independent*, neurons, which, for histological distinction, we have named *psychic*, and which, for a great part of our waking time, continue active, while the other two are, as it were, "switched off." Thus, during the waking state, unless the sensorium is engaged receiving sensory impressions, or discharging motor impulses, it follows, as a functional necessity, that it must be engaged in other work, conscious, and, it may be, sub-conscious, inasmuch, as its absolute functional abeyance is inconsistent with psychological experience, and law, and, therefore, that a part of that sensorium, and neuronal economy, continues to cogitate, or perform purely mental work, and to keep up the continuity of the process of cerebration. In that part of the process of cerebration, in which the histological channels of sensory, and motor, innervation, are, for the time, closed, and during which, it may be, a "connected process of thought" is being, evolved, or elaborated, or a general process of *thinking at large* indulged in, we are compelled to conclude, that an area, of the central

cerebro-neuronal materio-dynamic machinery, continues active, in the purely mental, or psychic, strata of cerebral texture, independently performing purely intellectual work, which, during the condition of sleep, or from traumatic, or toxic, influence, may also be "switched off" from the immaterial ego—this "switching off" representing a physiological provision, for the mutual rest, and recuperation, both of mind, and body, by which the material mechanism of cerebation is overhauled, and the generation, and re-distribution, of nerve energy, effected, for physiological, and psychic necessities.

Psychic neurons may, therefore, be supposed to effect the union of sensory, and motor, neurons, respectively, by virtue of their axonal processes, becoming histologically continuous with the neurons, on either side, without necessarily terminating in, any specific nerve terminal arrangement, other than that of direct, or modified, histological continuity. Such a central uniting area of neuronal structures, must, it is conceivable, represent a somewhat large proportion of those peripheral grey, and central white, textural developments of the brain proper, without, necessarily, requiring to be continued along the lines of either the sensory, or motor, nervatures, proper, and, therefore, to be within easily available reach of the operation of the mechanism, and hypnotic influence, of cerebral imbibition.

The psychic area of neurons, thus, represents a region of cerebral structure of indefinite dimensions, comparatively free from the disabling, or paralysing, influence, of purely sensory, or motor, neuronal molecular changes, and, therefore, secures for intellectual cerebation the means of continuing its operations, when all around, it may be, is reduced to complete functional inability, and temporary paralysis. This condition of functional independence, and aloofness, of the psychic neurons, is well illustrated, by *the onset of sleep*, and *the renewal of consciousness after sleep*, very variable, and indefinite periods of time, and psychological state, no doubt, but in this, it may be said, both the sensory, and motor, neurons, exist in a state of functional abeyance, quite, or almost entirely, complete, while the psychic neurons are still,

or become, functionally active, and capable of performing good work, both quantitatively, and qualitatively, but, more especially, after awaking; hence, it is frequently found, that a problem, which has been engaging much attention previously, is revealed in "early waking" thought, displaying itself almost spontaneously, in full proportions, and true perspective, without apparent mental effort.

Such is the cerebral habitat or, "*home, of the ego*," and such is some of the work done therein, by the true psychic neuronal textures, constituting the debatable cerebral region, dividing the two great areas of sensory, and motor, neural activity, in which are displayed the phenomena of afferent, and efferent, innervation, and affording a buffer region of neutrality, and calm, in which can be displayed the processes of thought, intelligence, and will, with all that characterises the mental outlook of the genus *homo*, as distinguished from his zoological, neighbours, and friends.

Neurologists hold, that both afferent, and efferent neurons, are histologically produced, and evolved, *once for all*, non-renewal following on their destruction; and the truth of the opinion becomes abundantly evident, when we consider that both nervatures correspond, in number, and extent, of terminal extensions, with the extent of sensory surface, and the number of muscular fibres, to be innervated, by the respective, sensory, and motor, nervatures. Whether the same doctrine may apply to the intermediate, or psychic, neurons, it would be highly interesting, and instructive, to know, but, here, the structures to be examined, are so minute, and complex, in their distribution, that it may easily be that the most elaborate research may fail to reveal this; however, we are warranted in saying, that, it is quite possible, there may be a difference in their histogenesis, which will allow of a growth, and increase, in the intelligence, during adult life, or after the growth of the body has ceased, and the afferent, and efferent, nervatures have reached their climax, or limit, of development, by increase in growth, and extent, of their dendritic, and axonal processes, if not of their actual numbers.

It may well be dependent on some such histological increase of the psychic stratum of neurons, that the lessening, or shrinkage, of the, sensory, and motor, strata, of the cerebral matrix, is "made up for," or structurally substituted, and that the increase in extent of intelligence, and depth of knowledge, is sustained, until such time, as senile changes begin mentally to manifest themselves, or as involution seizes on the materio-psychic being, and "closes the scene."

EXTRACT XXIX.

ON THE PSYCHIC OR MENTAL BRAIN CELLS.

THE psychic or mental neurons, as we have said, constitute the peculiar habitat of the mind, and, in the waking state, are ever engaged, more or less, actively in the performance of what constitutes mental work, conscious and sub-conscious, the latter resembling reflex action in the domain of neuro-muscular activity.

Mental cerebration occupies, on a rough estimate, two-thirds of a human lifetime and must, therefore, have, for the material accommodation of its neuronal machinery, a proportionate area of grey matter and correspondingly great dynamic facilities. Both these desiderata are, we think, abundantly supplied by the unclaimed areas of grey matter, or those not yet appropriated by the exponents of cerebral functional localisation, and, indeed, it may be assumed that mental neurons must be in immediate contiguity, if not continuity, with all the cerebral areas in which non-mental function is localised. We, therefore, would claim that the greatest proportion of the grey matter of the cerebrum is engaged in the work of mental cerebration and that "linked up" to it are the areas to which definite neuro-dynamic functions have been assigned. Be this as it may, however, the enormous areas quite untouched by the claims of localisation give to the requirements of psychic activity just that range of choice, so to speak, and that wealth of immediate availability which its supreme importance in the neuro-dynamic work of the organism requires and demands.

What position the psychic neurons occupy locally in

relationship to the sensory and motor neurons it is impossible to say, so far as observation and experiment up to now warrant any statement on the subject. It must of *necessity* be, however, that the cerebral neuronal commonwealth is so layered, or intermixed, that the linkage of the sensory, or afferent, and the motor, or efferent, with the psychic neurons is so intimate and direct as to require direct or continuous but insulatable and breakable histological continuity, and functional interdependence and oneness.

Viewed thus it becomes apparent that both the afferent and efferent, or sensory and motor, neurons, when long in active functional employment, become exhausted and require uncoupling from the psychic neurons, and that these latter likewise require rest, and so, when one psychic neuronal area has become exhausted from too prolonged use, another, or other, fresh areas can be called upon to take up the work of psychic cerebration until such time as the fatigued neurons have sufficiently recovered their psychic tone so as to be able to resume the work of active psychic cerebration. If it is consistent with universal experience that psychic cerebration is most effective, and successful, when freed from the necessity of attending to the calls of afferent and efferent, or sensory and motor, innervation, it follows that the periods of awaking from sound sleep, and before the sensory and motor neurons have had time to disturb the flow of psychic cerebration, and when the sensory and motor neurons have been completely inhibited from the psychic, coincide with the periods of most successful psychic cerebration, or intellectual exercise.

These views, histologically regarded, are consequently consistent with the ideas that the three forms of neurons, viz. the psychic, or mental, the sensory, and the motor, are each, and all, locally present, in a greater or lesser extent, in every section of cortical space and contained neurons within any and every area of the cerebral grey matter, and that the histological requirements of the doctrine of cerebral functional localisation do not preclude the existence in juxtaposition of all three forms of neurons. We may, therefore, take it that within the entire area of the grey matter of the cerebrum we have to deal with a

combination of the three forms of cerebral neurons, and that the white substance, in so far as it consists of the axonal processes of the sensory and motor neurons, connects the psychic neurons with the outer world and ministers to the requirements of consciousness and intelligence.

EXTRACT XXX. A.

ON THE NEURONS, GENERALLY.

THE central or systemic nervous system, growing out of, and supported by, the neuroglia, may be regarded as, a congeries of neurons, and each neuron may be regarded as consisting of a cell, with its contained nucleus, and nucleolus, the cell, by its wall, and contents, being continuous with the "white substance of Schwann," and its containing sheath, the nucleus, by its wall, and contents, being continuous with the axis cylinder, and its containing sheath, while the nucleolus rests within these, as an independent body, to which, we are of opinion, the sensory nerve impulses are conveyed, and in which, if unexhausted, they may be retained, or converted into motor impulses, and discharged; or where, on the other hand, if the impulses, or molecular nerve force movements, be highly specialised, as when they come direct from the senses, they may remain stored up, and available for future psychic use, as are, the negatives of the photographer, or as electric power in, Leyden jars, or the "accumulators" of the electric engineer.

The highest types of these neurons may be looked for in the cerebral cortex, and here the individual cells may be seen, taking root in, and from, the neuroglia, by apical, and collateral, dendrites, dendritic processes, or dendrons—these processes, more especially the apical, terminating in free radical extensions, from which, in turn, bud-like processes, or gemmules, project into the surrounding neuroglial substance, apparently, in a manner analogous to the rootlets of a plant, where they imbibe

by osmosis, the materials required for nerve nutrition, while the collateral, or parietal, dendrons, extend horizontally, by continuations of the cell wall, it may be, in union, or interlacement, with those of neighbouring cells; thus forming a supporting structure, or framework, apart from, but in conjunction with, the neuroglial, fibro-cellular, and unorganised substance, or glial cement.

The cells being thus fixed, and nourished, grow in a direction opposite to their apical, or radical, terminations, viz. in the direction of the axis cylinders, or axons, issuing from them, and thence continuously, by peripheral extensions, until the first synapse, or the first intercepting ganglionic cells are encountered, or interjected, in their course, until they terminate as motor fibres in the various muscular structures of the body, and limbs, until they end in the sense organs, or in the general peripheral cutaneous nerve endings, or until, by communicating filaments to the sympathetic nervous system, they end within the parenchyma of the various organs, or on the free surfaces of the various cavities, or hollow spaces, of the body.

The form of neuron, here described, may be regarded as, typical, or characteristic, of all the neurons individually, which go to make up the structure of the systemic nervous system as a whole.

The nerve cell of the *cortex cerebri*, varies in size, and shape, according to its position, depth, etc.; the nerve cell of the lower centres, is also characterised by variety of size, and shape, differences of function, and relationship, probably being the determining causes of this. The nerve substances, entering into the axonal structures of a neuron, are divided into medullary, and non-medullary, the latter consisting of the axis cylinder, the central, and conducting, part, of the nerve mechanism, an axilemma, or containing, sheath, surrounded by the former, the "white substance of Schwann," with its containing sheath, or neurilemma.

The cell is, thus, the investing substance, in which the true nerve elements, the nuclei, and nucleoli, and axonal fibres, are developed, and maintained, and, in, and from, which they grow, its chief function being that of select-

ing, and conveying, the needful nourishment for their maintenance, and insulating them from contact with the surrounding neuroglial structures, and capillary blood-vessel mechanism.

Being thus protected, insulated, and nourished, the nuclei, with their contained nucleoli, become subservient to, and perform the functions of producing, receiving, conserving, and distributing, of nerve force, the former, the nucleus with its continuation, the axis-cylinder, acting the part of conveyancer, the other parts of this complicated work being performed by the latter, the nucleolus, the only "independent" structure, in the hierarchy of the higher nerve elements, or bodies.

The axis-cylinder of the nerve fibrils, may be regarded as continuous with the intra-nuclear substance, in its inmost, or most intimate, molecular aspect, and the "white substance of Schwann," or medullary substance, as continuous with the contents of the cell body proper. The nucleoli must, thus, transmit, or convey, their contained, and produced, energy, directly into the substance of the axis cylinder of the fibrils, while the "white substance of Schwann," encased in its primitive sheath, and lined by the axilemma, performs the functions of, insulation, and protection.

The various structural elements of the neuron, are formed, or secreted, and circulated, although in a very different manner from the cerebro-spinal fluid, and are excreted, or exuded, in a likewise very different manner, the semi-solid, or plastic, materials, constituting, the "white substance of Schwann," and the axis cylinders, suffering an organised excretion, so to speak, in the form of epidermic scales, and appendages, epi- and endothelial cells, and scales, and the sarcous elements of muscle fibres. The quantity of material, thus removed from the body, must be regarded as largely, if not entirely, due to nerve fibre growth, and circulative disintegration, and elimination, but of course impossible of measurement by any known means—roughly speaking, however, we may regard the rate of *shedding*, of epidermic, and epithelial, scales, and the growth of hair, and nails, with the maintenance of muscular fibre, generally, as, to

some extent, affording an index of the rate of nerve cell secretion, and nerve fibre growth. Should this estimate be even approximately correct, we at once see that the rate of nerve cell secretion, must be relatively, a great one, and, therefore, that the *denied function of nerve cell excretion* must be one of corresponding proportions and dimensions, and, in fact, one of the largest, and most omnipresent, of all the excretions of the body.

The skin, or cutaneous covering, of the whole body, with the mucous, and serous, linings of the various passages, and cavities, large, and small, occurring within the body, represent, respectively, the areas of distribution, of the systemic afferent, or sensory, and the sympathetico-systemic nerve terminals, the muscular structures, striped, and unstriped, representing, in like manner, the respective areas of distribution, of the systemic motor, and the sympathetic, nerve terminals. Each of these terminals, has a form, and method, of terminal distribution, of its own, determined by the anatomical structure, and nervine requirements, of the tissue to which it is distributed, generally known by the name of arborisation, each of these arborisations being, the terminal expansion of a nerve fibril, and known by various names, according to the particular, form, shape, or manner, of its termination.

Each of these arborisations, or terminal expansions, moreover, represents the process, and manner, of exudation, or excretion, of the plastic component parts of a nerve fibril, and constitutes the final act of growth, of the individual nerve fibril, and its originating nerve cell—death, and disintegration, of the detaching material following, as soon as its vital connection, or attachment, ceases. Thus, the processes of life and death, follow each other, in the experience of every scale shed, and every organised particle released, from the sensory nerve organism, the vital connection, however, being still for a while maintained, when the motor terminal fibrils shed their contents, into the sarcous discs of the muscular tissues.

In the process of *shedding*, as seen in the breaking down of the sensory nerve terminal expansions, and the filling up of the voluntary muscle fibre discs, and unstriped muscle cells, by the motor nerve terminal expansions, we

have displayed to us, the concluding stage, of the development, and growth, of every peripheral neuron, sensory, and motor; the opening stages being the formation of the parent cell, with its nucleus, and nucleolus, and the projection of an axonal process along a nerve trunk, and finally its, outgrowth, and expansion, or termination, in the concluding intricacies of the nerve terminal developments.

This, therefore, we hold, proves, that every axonal nerve fibre originating from a cell (and they all originate thus), can only grow in a direction leading from that cell, that is, along the axon, which leads from it, as distinguished from its dendrons, which lead to it, and that, consequently, the long vexed question, of *the direction of the growth of nerve*, may be now regarded as settled, without the possibility of cavil, because it is settled on lines, dictated, and determined, by, and through, the medium of nerve histological continuity, and not by the manner, or direction, of the performance of nerve function, or the passage of nerve energy. In concluding, or summing up, thus, we must be understood as denying that nerve terminal extensions, by whatever name known, are in any respect to be regarded as nerve cells, or neuronal units, and, hence, affirming that it is impossible for a process of growth to be established, or maintained, by them, and that, therefore, growth, and renewal, of nerve, from its distal extremity, is an impossibility.

EXTRACT XXX. B.

ON THE NEURON, OR NERVE UNIT.

THE study of the neuron may be pursued, along the individual line, so as to afford a clearer view of the united, or general, lines, when we come to take up the subject of the neurons, in their co-relations to each other, and to the, so-called, non-nervous structures of the body. The neuron, as we have already said, is composed of a cell, with its contained, nucleus, and nucleolus, having attached to its outer, or containing, wall, a series of processes, or projections, called dendrons, or dendrites, together with one, or more, processes of a special structure, called axons, which represent the path, or paths, along which nerve impulses, sensory, and motor, pass, into, or out of, the cell contents. Covering the cell protoplasm, the nuclear, and nucleolar, bodies, is a series of neurokeratinous containing walls, of a very attenuated, but resisting, character, which, respectively, support, and separate, them, and which, with the probable exception of the nucleolar, are continued along the axons, and, it may be, to some extent, the dendrons. In the case of these latter, however, it may be premised, that protoplasmic separation, gives place to blending, or, at any rate, that the contained protoplasm has not begun to be, separated by, or insinuated between, containing walls, in quantity at all proportionate to that, which is regularly passed along the axonal processes of the nerve fibres, but yet in sufficient quantity, to permit of the collateral axonal or dendritic, communication of nervine molecular changes, between associated neurons, or groups of neurons, contiguity, if

not continuity, being thus secured, and combined, nerve, and intellectual, operations, made possible.

With the statement, or histological deduction, that the neuron is incapable of renewal, and that, as the systemic nervous system begins, so it must continue, so far as the gross number of its neuronal units is concerned, we find no fault, except that, it seems impossible, if it be absolutely true, to account for the extremes, of motor dexterity acquired, and the intellectual attainments possessed, or achieved, by certain members of the animal kingdom, and many individuals, and groups of the human family. In the face of these occurrences, if the number of the neurons remains the same, we seemed to be compelled to accept, of some such view as the following, viz. that the neuronal bodies remain in numbers unaltered, but that their textural attachments, prolongations, or processes, may undergo a change, both of addition, and subtraction, as when a neuron, or group, of neurons, are kept in sustained activity, or allowed to remain in functional abeyance, respectively. In the former, we think, we are warranted in assuming, that the lateral dendritic processes undergo a process of, strengthening, and acquired dexterity, so to speak, from exercise, while the latter droop, and atrophy, from continued disuse; this strengthening, and increased dexterity, so to speak, of amoeboid projection, of dendritic processes, begotten of continued, and well-directed, use, would, therefore, appear to meet the requirements of a belief, in the theory of the unalterability of the original gross number of neuronal units.

From the origin of the first neurons, in the incipient stages of embryonic development, amid the latent potential matrix of the epiblastic area, a process of continued, but strictly limited addition, or accretion, so to speak, of neuronal units, goes on, whereby the completed systemic nervous system is built up, and *projected* into every recess, and structure, of the meso- and hypo-blastic areas, thereby assisting in, innervating, vitalising, organising, and sustaining in life, these latter, and maintaining in one, living, and co-operating, whole, the combined sympathetico-systemic anatomical elements, of which living animal bodies are composed. The primitive streak, in succession to the

germinal spot, may be said to mark the origin of the systemic nervous system, in its process of evolution from the primitive developmental elements of the completely formed spermo-germ body, and to represent the laying down of the foundation members of the, greater, and smaller, neuronal structures, comprised within the brain, cord, and nerves, or systemic nervous system. The elements of the embryo, from which the systemic nerve structures are built up, are the first to respond to the operation of the developmental impulse, and to betake themselves to organised, and organising, activity, or to the work of organisation, hence we find that, that organising work extends, in the directions in which the nerve textures are, in future, to be discovered by the anatomist; the nerve elements would, therefore, seem to initiate, dominate, and determine, the direction, and manner of arrangement, of the non-nervous elements of the growing embryo, consequently, we must recognise, that the nerve structures, must inter-penetrate, and be co-terminous with, all organised matter, and, also, that we must find actual nerve plasma in the elements from which they are developed, in all parts of the organic whole. These nerve elements, originating at the centre, and being continued in unbroken structural sequence to the periphery, of the body of the embryo, and into its nascent muscles, necessitate not only an unbroken histological connection, solid, liquid, or plastic, but a formation, or growth, beginning at the centre, progressing to the periphery, and muscles, and terminating there, in exudation, or disruption, or by being finally shed—this peripheral disposal, taking the organised forms of, epithelium, epidermis, hair, nails, etc., and the sarcous elements of muscle.

We are further of opinion, that the “process of growth” of the systemic nervous system, begins in the sympathetic, or truly trophic, neurons, if we may call them so, and that these initiate, the process of growth generally, throughout the entire area of developmental activity, not only within the nervous system proper, but throughout the musculo-skeletal, and the whole extent of the, so-called, non-nervous, living tissues, and organs,—this process of growth being alike throughout the entire animal kingdom;

or at anyrate wherever the elements of a systemic nervous system are to be detected, whether scattered, or organised ; therefore, the sympathetic, or trophic, neurons, having primarily arranged themselves in definite groups, or ganglionic aggregations, assign to each of themselves, the superintendence of a *definite area*, in virtue of which, the life, growth, and functional activity, of that area, are sustained, the health of the individual areas, necessarily, eventuating in the health of the whole. The nervous systems of a large portion of the lower animal world consist of, just, such elements as are here described—as we ascend higher, however, in the scale of being, we see gradually taking place, the addition of more highly *organised parts*, to these *almost automatic* nervous systems, until, in the highest ranges of animal life, a brain, spinal cord, and systemic nerves, are introduced, in increasing completeness, and complexity, when in the end we realise, in *ultimate perfection*, the *union of the systems*, in man himself, each with its functional rôle respected, and its material development, and evolution, fully matured. Further, we are of opinion, that these two systems, the sympathetic, and systemic, can, and do, act, both conjointly, and independently, and that during sleep we see the sustained, and independent action, of the sympathetic, or trophic nervature, as it is to be observed in the earliest stages of embryonic existence, and during paralysis of the cerebro-spinal system in any particular part, or parts, of the body. We thus perceive, that the structural integrity of the affected part, or parts, is maintained by the same instrumentality, but, that while the life, and structural integrity, of the part, or parts, in question, are thus maintained, we become conscious, at times, that changes of a retrograde, or degenerative, character, are in progress, and that the muscles are undergoing processes of involution, in virtue of being cut off from the sustaining, influence, and pabulum, supplied by the motor nerves distributed to them ; also, that the skin, in like manner, suffers, from the same deprivation on the part of the sensory nerves distributed to it, becoming sleek, smooth, and attenuated (Paget's "glossy skin")—sometimes to the proportion of a mere pellicle, in which becomes visible to the naked eye, as the sensory nervature atrophies, and

recedes, the almost complete mechanism of the cutaneous blood circulation. The epidermis, with the skin appendages, and the muscular tissues, generally, having suffered, degenerative, or obliterative, changes, to a greater, or lesser, extent, according to the time, and degree, to which the invading paralysis has extended, the necessity for believing in the reality of a dual nervous system, becomes established, and the truth of the opinions, long held, and expressed, by authorities on the subject, is made manifest.

The neurons, composing the cerebro-spinal nervous system, would seem to grow, and to be added, according as the necessity for their production arises, by the increasing needs of the muscular system, on the one hand, and, on the other, as the sensory necessities of the organism become more complicated, and as the awakening, and growing, intelligence, calls for more, and more, fully developed nerve instrumentalities, or agencies, to meet its continually increasing demands. These views coincide with those arising from a study of the changes undergone by the evolving, or growing, cerebro-spinal nervous system; thus, the pre-vesicular stage of its development, coincides with the entire absence of proper nerve phenomena, apart from those of *mere vegetation*, so to speak, while the *closing in*, *vesiculation*, nerve cell genesis, and *fibrilisation*, of the nascent nervous system, synchronise with the growth of a musculature, and its innervation by motor neurons, and with the projection of the elements of a sensory nerve mechanism, into the outer coverings, and inner linings, of the embryonic textures—the protoplasmic pabulum, required for the accomplishment of these changes, being supplied from the latent glioid stores lying within the ovum. After these early stages of nervine development, and when the ovum has been exhausted of its available supplies, a circulation is established in the embryo, of the more highly developed members of the scale of animal life, through the instrumentality of which, supplies are brought from the circulation of the maternal structures, and conveyed to the matrix of the ganglionic nerve centres, where they become directly available, for nerve cell growth, or are laid down in the form of a material known as neuroglia, from which they can in future be taken up, by the nerve cells, as

needed, or where they can be retained, as conveniently available nerve pabulum. These latter changes coincide with the thickening, and shrinking, or convolution, of the cerebro-vesicular walls, the partial obliteration, or narrowing of the neuro-vesicular cavity, and its definite curtailment, to the proportions of the cerebral ventricles, and the central canal of the cord, and are co-extensive with the duration of life, or, at any rate, of that period of life connected with its adult activities, physical, and mental.

Life, so far as it is dependent on the integrity of the nerve structures, terminates, in accordance with the manner, and order, of failure, of the dual nervous organ, first, it may be, by a break down, in one, or more, parts, of the cerebro-spinal system, and second, it may be, by failure, in part, or in whole, of the sympathetic, or trophic system, the former, not necessarily, terminating the life of the individual affected, the latter, however, terminating in death, partial, or complete, accordingly as it is local, or general—in other words, in gangrene of a part, or in death, of the whole body, recovery being possible in the former degree, but impossible in the latter—*inevitable death*, partial, or complete, occurring in all cases, showing that, the incidence of mortal change, is largely, if not entirely, due to the cessation of trophic changes, thus demonstrating as it, the sympathetic nervous system, is the first, so it is the last, part, of the combined nervous system, to dominate, and maintain, the continuity of vital action, or life.

EXTRACT XXXI. A.

ON NEUROGENESIS, OR NEURONOGENESIS.

NEURONOGENESIS signifies the origin, and development, of the Neuronal or Neural unit, the totality of which constitutes the systemic nervous system.

The neuron is generated from the basal neuronie substance known as the Neuroglia, and owes its origin, therefore, to the preparation, and deposition, of that substance within the blastodermic area known as the ectoderm. This basal substance in brain, cord, and ganglia, after primary deposition from the differentiating ovum, originates, and develops, the spongioblasts, which in turn evolve the individual nerve cells, and neural processes, dendritic, and axonal, which ultimately inter-penetrate, and innervate, the meso- and hypo-blastic related areas, and constitute, with the sympathetic nervous system, the dual nervature which controls, and determines, the vegetative, and higher organic, life, of the completed organism. The neuron, besides originating in, and growing from, the neuroglia, continues to draw from that substance its materio-dynamic supplies, through which it secondarily unites itself with, and supports, the structures known as, the skin, and the muscles, by circulatory transference of matter and energy along the axonal processes of the sensory, and motor, neurons, respectively—these axonal processes being *hollow tubes*, or *vessels*, and not *impervious filaments*.

The nutrition of the systemic nervous system is, therefore, due to the continuance of these neurogenetic conditions on the evolution of the hæmal circulation, when the nutritive plasma is deposited from that circula-

tion in the substance of the neuroglial areas, where it becomes available for absorption by the nerve cell dendrons, for plastic arrangement by the cell and its nucleus and nucleolus, for circulatory disposal by the axonal processes to the related skin, and muscle, structures, by direct continuity of histological circulatory channels, and for subsequent structural incorporation with the textural elements of the skin, and the sarcous elements of the muscle fibres, through the sensory, and motor, fibres, respectively. Each neuronal unit, as thus produced, and nourished, becomes subservient to sensory, motor, or psychic, purposes, according to its histological position, and relationships, and remains devoted to its originally assigned work, so that no one unit can take the place of another, nor the gap be filled up when one is removed.

Sleep affords a diurnal opportunity for the renewal and redistribution of neuronal substance, and nerve energy, by sympathetic nerve agency, and thus becomes the means of the proper "linking up," and reciprocal, or co-ordinate, working of the combined systemic, and sympathetic, nervous systems.

The evolution of the systemic nervature from the neural division of the neurenteric canal resembles closely the evolution of the alimentary, and associated, organisms, from the enteric division of that canal, these two great developmental processes jointly securing the innervation, and nutrition, and, therefore, the life of the entire organism, material, and dynamical. In effecting these results we must recognise the principle of circulation as the chief instrument, the operation of which along definite lines of vasculature, and inter-space areas, effects the arrangement of the formative elements into textures and organs, suitable for carrying out the organic and functional work of the living body, by a process of continual transference, whereby the new elements of food and drink assume the structural form of every tissue, and finally represent the residual or complete result of all intra-corporeal vital change, and activity.

EXTRACT XXXI. B.

ON NEURONOGENESIS, OR NEURAL HISTOGENESIS, AND NEURAL NUTRITION.

As we have said, the neuron may now be regarded as the neural unit, and the Systemic Nervous System may be regarded as the total embodiment of these units, and hence as the completed nerve hierarchy, in virtue of the possession of which, in its highest type, man occupies the crowning position in the evolutionary progress of the forms of life yet known to science, and the *facile princeps* of psycho-physiological developments.

The neuron may be said to exist, merely in embryo, or anticipation, in the great domain of vegetable life, and in that of animal life innervated by a sympathetic nervature, as well as in those structures and organs outside the systemic nervous system dependent on sympathetic innervation, including the basal substance, and neuro-dynamic elements, of systemic innervation, psychic, and neural, cerebral, spinal, and peripheral. That being so, by closely observing the disposition of the matrix in which the future systemic nervous system is to be developed, we become aware of the preliminary preparation of a great amorphous collection of a somewhat faintly organised "medullary" substance within the areas of future systemic neuronogenesis, to be known in the future by the name of neuroglia, and to be found deposited wherever the neurons take their origin, whether in the brain, cord, or ganglia.

This substance, the neuroglia, may be regarded as the materio-dynamic *sine qua non* of all neuronogenesis, and the potential matrix, out of which grow, or in which are

planted, produced, and reared, or evolved, the potential cell elements of the coming systemic nervous system, by the action, or operation, of the sympathetic, or innate, selective, and formative, energies of the fertilised ovum, on its stored, and actively vitalised, material. During this stage of early embryonal, or blastodermic development, and differentiation, a structure hitherto unknown in the formative activities of organic perpetuative vitality is thus introduced, by the advent of the ectodermal into the united, and dual, régime of meso- and hypo-dermal evolution—a régime which has hitherto met all the necessities, and requirements, of vegetable, and vegetative, life, and which has made possible the introduction of an entirely new, and higher, specific method of organisation, by which the way has been paved for the production of the *genus homo*, with all the distinguishing characteristics of humanity, physical, mental and moral. Thus has been marked one of the greatest epochs in the history of living forms, as they have existed in the past, or from the beginning, and one of the most profound, and far-reaching, of the developmental changes undergone by the embryonic organism of man.

The ectoderm is the structural foundation laid down by the sympathetic nervature, and its elements are so arranged that the formative energies by which they are inspired, so to speak, initiate, and fully effect, the hitherto unknown process of neuronogenesis, and lo ! a systemic nervous system has been added to the economy of organic evolution, and to the formative activities of the higher animal life.

The process of neuronogenesis resembles that of general histogenesis, but is specifically different in many of its details, and organic results ; thus the phenomena of proliferation, by which the renewal, or substitution, of lost cells is effected in so-called non-nervous textures, are conspicuous by their absence, and it follows that systemic nerve cells once lost are never renewed, and that the structures dependent for their support on those cells also perish. Neuronogenesis is effected gradually, as the ectodermal textural area becomes mingled with, and incorporated in, the meso- and hypo-dermal textural areas, single neurons, or groups of neurons, of spongioblastic origin, being added, more or less rapidly, as the process

continues, until the whole combined areas have become one for material, and functional purposes, and a complete human organism evolved.

The nerve cell as it develops from the spongioblast takes unto itself structural characteristics, material, and dynamic, by which it is enabled to traverse, and functionate, the embryonic elements, to the extent permitted to the systemic nervous system functionally to affect the meso- and hypo-dermic areas, while it throws out dendritic processes, through which it texturally supports itself with nourishment from the neuroglial matrix, and develops an axonal process, or processes, through which it effects a union with distant structures, such as the muscles, and skin, at the same time evolving within itself a nucleus, and nucleolus, which perform the specific functions of innervation, and harmonise, and co-ordinate, the working of the materio-dynamic agencies of the systemic nervature, within itself, and in union with the sympathetic nervature.

The formation of each neuron is followed by its dedication to a particular work in the economy of innervation, either as sensory, motor, or psychic ; or as linking up the various forms of neurons within the systemic nervature, and combining in a composite, and co-ordinated, whole, the dual nervatures, systemic, and sympathetic.

The completed nervous system is, therefore, a compound of innumerable neurons of differing functional ability, according to the nature of the particular locale occupied, and the particular neuron work entailed by that locale ; thus they may be—(a) receivers of sensory impression ; (b) communicators of nerve impulse ; (c) participators in psychic cerebation, or, (d) vehicles of exchange in the balancing of the systemic, and sympathetic, nerve energy.

Each neuron secretes, and grows upon, neuroglial plasma, and, contrary to current belief, excretes, or passes that plasma, along its axonal process into the texture with which it is functionally, and histologically, connected ; thus the two great divisions of the systemic nervous system terminate in, and become continuous with, the proper elements of the skin, and muscles, respectively, and thereby effect both a material, and dynamic, continuity, and oneness, between the proper neuronal struc-

tures, the dermal envelope, and the musculo-skeletal framework of the body.

In so doing we must come to the belief, or be forced to the conclusion, that the doctrine of non-excretion by the nerve cell is untenable; and must, therefore, be prepared to concede that it also excretes, and necessarily along the lines of least resistance, the lumina of the axonal fibre, or fibres—the white substance of Schwann, and the axis cylinder substance, being the materials excreted.

This again presupposes, and necessitates that the axons of all nerve cells, which have been hitherto regarded as homogeneous filaments, capable only of transmitting nerve energy, are twice hollow tubes, enclosing, and transmitting, respectively, the insulating, or white substance of Schwann, and the proper neuronie substance—the axis cylinder—these two substances being due respectively to the selective, and formative, energies of the cell, and its nucleus, respectively, whose containing walls are continued along each axonal process as the primitive, or containing, membranes, of the two substances.

Viewing the neuroglial matrix, as the common neuronal histogenetic source, and as the result of sympathetic neuro-dynamic formative activity, both in its original development, and its subsequent continual renewal, we discover that its embryonic formation preceded that of the blood, and its circulation, and that it subsequently became inter-penetrated by that circulation, and dependent upon it for nutritive supplies, they being delivered not directly to the neurons, but laid down amid the feltage of the neuroglial matrix, to be taken up as required by the dendritic processes of the individual neurons.

Neuronal nutrition is, therefore, not effected by direct delivery from the blood vasculature, but through intermediate neuroglial agency, where the neuronal plasma has been laid down, and stored, for use when neuronal necessity calls for it, and where it can thus be constantly obtained, free from the exigencies, and uncertainties, of a direct blood circulatory supply, and in quantities according with both particular, and general, neuronal requirements.

This is a nutritive process conducted on somewhat similar lines to those on which alimentary digestion, and

absorption, are effected, and may be regarded as what might be called a *secondary digestion* of the neuroglially prepared plasmal elements. As neuronogenesis determines the material nature, and functional character, of each neuronal unit, so the individuality of each is maintained, by a continual devotion to individual work, amid the many co-ordinated duties in which it may be called upon to act, and thus the occurrence of automatic ability becomes superadded by continuous use within, more or less, definite limits.

As excretion from the nerve cells necessitates the existence of hollow axonal processes, so does the onward passage, or circulation, of the axonal substances require the provision of outfall spaces into which these substances can find a means of disposal, or progress, and along which they can find a means of final disposal; because it is neither logical, nor biological, to suppose that living, or organic, substances, can be otherwise disposed of than by some form of circulation, or movement, away from, and out of, the original, and determining, source of movement. Neuronal circulation must, therefore, find outfall facilities provided amid the elements of the dermal matrix, on the one hand, and into the voluntary musculature, on the other; and that we contend is what is to be found in both neuronal modes of axonal termination. In the former, or sensory, mode of neuronal termination, we find that the terminal fibrils, in the form of arborisations, break up into dermal cells, and ultimately into epidermal scales, which finally become detached, and fall off, or exuviate; while, in the latter, we find that the neural, and sarcous, elements, become continuous through the merging of the neurilemma, and sarcolemma, into one unbroken sheath, in which case we are compelled to recognise that the proper sarcous substance owes its origin to the original neuronogenesis, and neural circulation of the white, or medullary, and the axis cylinder, substances. Thus we see, and consider ourselves warranted in claiming, that the neurons are productive alike of nerve energy, and nervine substances, and that the latter are circulated along their axonal processes, and become structural elements in the growth, and maintenance, of skin,

and muscle, respectively—the truth of which statements is at once negatively obvious in the pathological conditions known as—to mention only two, “glossy skin,” and “myopathy.” Hence, the formidable, but altogether reasonable, conclusions, must be drawn, that the external endowment of the human body known to science, art, and poetry, as the skin, and those structures so much loved, and fondly developed, by the athlete, as the muscles, are alike the products of silent neural growth and circulation; and, therefore that a consistent, and reasonable, search after, and cultivation of, them, on lines thus dictated, cannot, and will not, be disappointed, because founded on the unalterable basis of cause and effect, of physiological nutrition, growth and development. Thus a proper nutritive supply, in quantity and quality, a continued maintenance of the patency of the circulating ways through which the formative plasma must pass, and a proper assimilative reception of that plasma by the cutaneous, and muscular, structures involved, must of physiological necessity be followed by altogether unobjectionable results—being due to the operation of normal laws, and conditions—while, at the same time, it cannot be wondered at that the stiffening, and blanching, effects, of time, lead to whitening, and denudation, of dermal appendages, wrinkling of the once smooth skin, and shrinking of the once packed, and resistant, muscles.

Besides our arteries we have, therefore, to reckon with the neural vasculature, and with the incidents of neural change, in the estimation of the process of “aging,” and the progress of senility. In ministering to the nutrition of the systemic nervature in all its parts, and jointly with the sympathetic nervature, in sustaining the nutrition of the dermal, and musculo-skeletal structures, the neuroglial matrix may be said to resemble the blood in its nutritional relationship to the non-nervous structures, so called, of the body generally, thus from them are taken up, respectively, the nutritive plasma of the sympathetically innervated structures, and organs, and the systemically innervated textures, neuronal, dermal, and musculo-skeletal. The recognition of these facts is sufficient to

point out, and to prove, that within our bodies there are two great acting, and determining, entities, which are known as the sympathetic, and systemic, nervous systems, inextricably blended for communal functional work, but which are capable of separate, and independent, action, in all individual functional effort, the two combining, in the normal, or physiological conditions on the strictest principles of reciprocity, inter-dependence, and independence, according to systemic, or physiological, requirements; and the one, the sympathetic, acting continuously, and the other, the systemic, acting periodically, or diurnally, according to well-defined physiological conditions, and laws, while, in conditions pathologically disturbed, the principles of action are dominated, and determined, by the strongest, and most effective, materio-dynamic impulses, with formative results accordingly as these work out in the physiologico-pathological struggle.

During the developmental changes taking place in the process of neuronogenesis, the neurons, as they are evolved from the neuroglial matrix, become encircled individually with a peri-saccular, and peri-axonal, sheath, containing a layer of neural lymph which is projected along the axonal processes, forming a fluid protection for their delicate contained structures, and accompanying them to their terminal extensions, and in addition, where they proceed along the nerve trunks leaving the cerebro-spinal canal, being received, and surrounded, with a neurilemmar extension sheath, continuous with the meningeal linings of that canal which, in turn, accompanies them to their final, or terminal distribution in the skin, or muscles, or along the *rami communicantes* into the sympathetic nervature.

Such neuronogenetic anatomico-histological arrangements secure that every unit of neuronal structure is encircled by membranous envelopes and floated in fluid, and also that the completely evolved systemic nervous system in all its parts, is surrounded by, secured to, and protected from, its non-nervous related structures and organs, free to perform its manifold functions, material, dynamic, and physic, with security and precision, with leakage of its specific materials and energy prevented, and

its faculties of renewal and redistribution of the common supply of these kept up to the physiological standard.

The systemic nervous system is thus the product of the sympathetic nervous system, and exists on plasmic matter provided by that system, as well as largely on potential energy produced by that system—physiological circumstances which ensure absolute precision in the combined materio-dynamic working of the two systems, and the greatest possible and best possible output of vital production, physical, chemical, and vital, on the part of both systems. Moreover, the highest or psychic form of work is only possible when the psychic neurons have been rested and refreshed by inhibition from neural contact, sensory and motor, in the form of sleep, during which the ever-active sympathetic nervature renews lost or spent neuronal energy and material, and refits the mind, the psychic being, for intellectual occupation or psychic cerebration, and the sensory and motor nervatures, as well as the musculo-skeletal structures, for another period of activity.

The histological continuity or contiguity of the entire units of the neuronal commonwealth, its growth from the same nutritive matrix, and their circulatory distribution to the skin, and musculo-skeletal framework of the body, by its sensory and motor axons respectively, provide a self-contained materio-dynamic organism, which, with its sympathetic partner, is capable of performing a kind and an extent of work altogether unapproached in the scale of animal performance and reserved for man alone.

In conclusion, we would generalise to the effect that although the ectodermal extension into the meso- and hypo-dermal areas somewhat overshadows, in extent and importance, the mutual extension of these two latter into the domain of purely neuronic growth and development, it is more apparent than real, inasmuch as it is found that all three have been progressing on lines mutually advantageous and necessary to complete the future complete organism. Thus, as the neuronal axons become structurally one with the muscle plates, the axonal circulation finds a ready prepared non-neuronal textural basis into which it can empty its contents along definite lines and in definite quantities, and which, guided by these

lines in definite direction, at length becomes the sarcoous or true muscle substance of the invaded muscle plates, and thereafter become arranged in relation to the future skeleton according to the specific requirements of every part of the organism in regard to movement and the other functions of a muscular system.

In this developmental process we see the same evolutionary principles and factors at work as we see in the formation of the alimentary canal, and its related digestive and circulative agencies for purposes of the preparation of the raw materials of the food for the purposes of future nutrition, and in the elaboration of a blood circulatory machinery which will carry these elements of nutrition to every structure of the body, and, with its related lymphatic vasculature, perform the functions of a great drainage system, all which formative phenomena in their organic results but prove the *universality of the principle of circulation* as the actuating and guiding agency in the vital work and physiological activities of the human, and all animated bodies, and that there are no insuperable obstacles or impervious barriers to the regulated onward passage of nutritive as well as effete material, either in mass or in molecule, a truth expressible by the paraphrase:—*circulatio circulationum, omnia circulatio.*

EXTRACT XXXII. A.

ON WHAT IS SIGNIFIED BY THE EXPRESSION—"THE NERVOUS SYSTEM," IN CONNECTION WITH LIFE, NUTRITION, AND VITAL RESULTS.

THE nervous system is an expression, the origin of which it would be as interesting to know, as it would be difficult to discover, as the history of medicine, from a very remote period, would have to be ransacked for the first mention, in the abstract form, of the subject.

So remote, however, from the modern understanding of what is meant by the expression, would that knowledge be, that our ignorance is not altogether a matter for regret, inasmuch as, did we know, we would be compelled to unlearn much, before we could take up the subject of its present-day signification, with the hope of still further, adding to its true interpretation, and aiding its adaptation to the solution of, practical, as well as, transcendental, neural problems.

What then, in short, do we mean to convey by the phrase, "The Nervous System"? We mean to convey, among other things, that it is responsible for the existence of life, that it determines the operation, and administers the laws, of life, within the organic body, and that, through, and by, it, is afforded a means, whereby psychic phenomena are made possible of accomplishment, and the higher, or immaterial, and dynamic, destinies, of man, evolved, and added to, the possessions of this last born, of all the races of animate beings.

The nervous system, in man, and the higher animals, is a dual organism, composed of two systems, called,

respectively, sympathetic, and systemic, and these two systems comprise all the nervous, and so-called non-nervous, living tissues, systems, and organs, of the body, *i.e.* they not only, vitalise, innervate, and co-ordinate, these tissues, and organs, but, in the true sense, constitute them, those belonging to the lower organic, or vegetative, department, of the organism, constituting the sympathetic nervous system, and those belonging to the higher organic, or voluntary, and psychic, constituting the systemic nervous system. The whole living structures of the body, therefore, are claimed, as nervous, and belong to one, or the other, of the two nervous systems, the only exception, if exception it can be called, being where the two systems intermingle, or overlap, in which cases, there is structural provision for dual control in the performance of common functions, the two possessing the power of acting conjointly, while able, at the same time, to do the work individually, and independently, when called upon, from any cause, physiological, or pathological, to do so.

Life, therefore, with all that it implies, is the product of the nervous system, and the outcome of its vital action, and the play of its energy, on the raw materials, or inert matter, on which its organic continuance is dependent, and the supply of which, constitutes *the living organism's great daily necessity*.

The nervous system being, thus, responsible for the maintenance of life, and the fashioning of the material structures by which the functions of life are performed, must, necessarily, be in the most direct union and sympathy, structurally and functionally, with the whole living organism; what then more essential than, that it should *actually constitute* that organism, supplying the pabulum on which it exists, and keeping in functional, oneness, and mutual dependence, both the material, and the dynamic, results, of its entire organic work, vegetative, and voluntary?

The central organic work of nutrition, therefore, is effected by the nervous system, by itself, for itself, through the co-working, for communal purposes, of that vast array of structural arrangements, and adaptations, of cell, and fibre, canal, and vessel, tissue, and organ, nerve, muscle,

and bone, which together, make up the living human body. Evolution, here, from the unicellular into the multicellular organism, by gradual structural accretion, and advancement in organic complexity, has secured the control, and working, in harmony, under nervine administration, of this vast organic cosmos, as it has done, in every other observable sphere throughout the domain of nature, animate, and inanimate. "The Nervous System" is, therefore, synonymous with what constitutes the living body, being, at once, the dynamic source of life, and the organic controller, and sustainer, of the formative impulses, by which development has proceeded, from cell to cell, and tissue to tissue, until the completion of the organism has been effected, when it, still, is able under ordinary circumstances, to maintain its vital continuity for a certain period, or until the, forces, and conditions, of dissolution, more than counterbalance those of life.

The nervous system, thus, warrants us, in claiming for it, a position of ubiquity, and importance, in the living human body, comparable only to that claimed for the principle of circulation, where we embodied the idea in these words: *circulatio circulationum, omnia circulatio*; we would, therefore, advance the opinion, that a similar form of words is required, to express, and to accentuate, its truth, viz. *nervus nervorum omnia nervus*.

The nervous system, or organic all-in-all, becomes, therefore, the living framework, or loom, through which the "weft and the woof" of life are passed, and woven into the duplex fabric, of organic work, and of "thought, word, and deed," by the agency of continuous circulation, material, and dynamic, determined, and operated, by vital activity, in obedience to the "laws of life," and the "presiding ego," and its implied sympathetic and systemic, "division of labour," and the resultant dual, and communal, output.

EXTRACT XXXII. B.

ON THE EVOLUTION OF THE SYSTEMIC NERVOUS SYSTEM.

THE systemic nervous system is evolved from the wall of the posterior, or dorsal, limb, of the neurenteric canal, which has been separated from, and reunited to, the anterior, or ventral, limb, by the interposition of metamorphic textures, which afterwards serve to keep them in continued modified structural, and functional, relationship. The metamorphic textures, here meant are those forming the outlet channels surrounding the olfactory projections of the anterior cerebral vesicle, together with the optic, and otic, outlets, the pituitary outlet from the cerebral infundibulum, and the coccygeal outlet, or termination, of the spinal meningeal cavity, and the thecal investment of the cord, represented by the *filum terminale*, and its coccygeal termination—all of which outlets persist to the end of life, and maintain, or afford, facilities, for the excretory disposal of superabundant cerebro-spinal fluid, and waste, cerebral and neural, material. This excretory provision is supplemented, and completed, by the sweat glands, through their connections with the inter-neurilemmar, spaces, and lymph channels.

In the wall of this posterior limb, of the neurenteric canal, are laid down the structural elements of the budding systemic nervous system, at first in most rudimentary form, but, subsequently, by evolutionary stages, in increasingly organised, and specialised, form, until the finished systemic nervous system appears, in all its completeness of structural detail, and functional capability. The wall of this

canal, therefore, undergoes a continuous thickening, and structural organisation, by a process of deposition of neuroglia, from the blood circulation, within the meshes of its fibro-cellular basis, where, at last, there begin to appear the rudimentary elements of nerve cell, and fibre, in an increasing number, and variety, until the fabric of the complete systemic nervous system is at last laid down, amid the supporting, and evolving, structure, of the sympathetic nervous system, part of which constitutes the histological structural element of the neuroglia.

Evolved from, and founded on, the sympathetic system, the systemic nervous system ultimately rules over, that part of the human organism destined to determine its thoughts, words, and actions, and to enable it to perform the duties of a conscious, and thinking, being, in contradistinction to, and in supplement of, the merely organic, or vegetative, rule of the sympathetic nervous system, which is responsible for maintaining, the continuity of life, and every organic, and nutritive, process, conducive to it.

The completed systemic nervous system is composed of brain, cord, and nerves, each of which is evolved from the original embryonic structural elements, necessarily sympathetic, in their earliest stages, but which, ultimately, undergo a structural, and functional, differentiation, so complete, as to constitute an entirely new, separate, and voluntary, nervous system, suitable to the supra-organic wants of an articulate, motile, and reasoning being. Needless to say that this systemic nervous system can be observed in gradual process of evolution, in the various stages of human embryonic, foetal, and post-natal development, as it is to be seen in its various stages in systemically innervated creatures, from the lowest to the highest ranges ; and needless to say that each stage of the developmental advancement, suffices to meet the systemic wants of that stage. Needless, also, to say that the systemic nervous system represents the highest form of organised matter, and the only form, through which, the highest, and most subtle, form of energy known to science, if it can be said to be really known, can operate, by consciousness, and will, thought, and ideation.

The systemic nervous system, moreover, represents a nutrition effector, inasmuch, as by its cell processes, it takes up from the neuroglial amorphous elements, the pabulum for its own cell growth, and axonal extensions.

Along the fibro-axonal extensions of every nerve cell, this neuronal nutritive pabulum is passed from the cell, by regular circulation, or growth, to the various textures in which the nerve terminals, afferent, and efferent, are histologically distributed, and with which they become histologically continuous. The nutritive process here indicated reaches, therefore, by continuity, every texture histologically related to the systemic nervous system, along a neuro-vasculature, the lumen of which is patent enough to allow circulation of axis-cylinder substance, and medullary substance, respectively, materials, which traverse their respective containing membranes, along every axonal process, and which ultimately reach the periphery of the systemic nervous system, and become structurally incorporated by the textures in which they terminate, or continue farther circulating by continuous histological succession, until these facilities become exhausted, when they are, necessarily, finally arrested, or shed, or returned into the blood stream. All these nutritive phenomena require for their accomplishment, the existence of circulatory facilities, and these facilities, we contend, are to be found in every axonal fibre, with its histological continuations, wherever they lead to—these fibres and their continuations being patent, and pervious, to the passage of the nutritive materials taken up by the nerve cells, and their contained nuclei, hence the skin, on the afferent side of the nervous peripheral extensions, and the muscles, with their attached tendons, intervening periosteum, and bones, on the efferent side of the nervous peripheral extensions, respectively, represent the structures to which the nutritive neuronal material is conveyed, as nutritive pabulum, or excretional material.

This nutritive rôle, which we have assigned to the systemic nervous system, embraces a large proportion of the nutritive work of the body, at least it embraces the nutrition of the whole structures subserving the functional work of the central, or systemic, nervous system, with the

exception of the non-functional, or passive, structural elements of the nerve structure proper, and the interstitial elements of the structures, such as muscles, subservient to the functional purposes of the systemic nervous system, generally; these latter being supplied, necessarily, directly from the blood circulation, through the agency of the sympathetic nervous system.

The systemic nervous system is entirely the product of the sympathetic nervous system, according to these views, and is elaborated and evolved, by it, in accordance with the formative impulses resident in the embryonic organism, whereby is realised the organic axiom, that "like produces like," plus "progress." The sympathetic nervous system, moreover, constitutes, in perpetuity, the living framework by which it, the systemic nervous system, is supported, and supplies the neuroglial pabulum on which it subsists, and the neural nourishment, which it circulates along its axonal fibril developments to become, in turn, the nutritive pabulum of every texture in which they terminate primarily, and, by histological continuity, secondarily.

The limits of the nutritional functions of the systemic nervous system, therefore, are reached, at the epidermis of the skin, in which the afferent nervature terminates, and where, the nutritional rôle completed, the erstwhile nutritive materials, are finally shed, and in the medullary contents of the skeleton, to which the voluntary musculature is attached, and into which the efferent nervature pours, by histologically continuous channels, its residuum of neural plasma, to be dealt with by the active retro-hæmogenetic elements so widely distributed amongst these contents. The cerebro-spinal lymph, and also the nervine nutritive plasma, being at all times liable to invasion by pathogenic agencies, become, necessarily, the bearers into every region supplied by the systemic nervature of chemical, physical, bacterial, or other *materies morbi*, where they leave them to perform their pathological work, in accordance with the laws of pathogenic evolution, when the result is determined, by the operations of the *vis medicatrix naturæ*, plus, it may be, the contributions of science, and art.

Who will deny that, along these lines, nature delivers a large proportion of her pathogenic agencies, to accomplish

ends, the meaning of which is not yet intelligible to us, but the effects of which continually cry out for, our sympathetic consideration, and the use of our best endeavours, to avert, to ameliorate, and to obliterate them, and their baleful effects ?

EXTRACT XXXII. c.

ON THE EVOLUTION OF THE COMMON NERVOUS SYSTEM—SYMPATHETIC AND SYSTEMIC.

THE sympathetic nervous system, we contend, is synchronous in origin, and in production, with the whole living structures of all creatures not supplied with a systemic nervous system ; that is, it is, or represents, the sum of the vital principle, the organic units, and everything that goes to make up the sum total of merely organic life, be it vegetable, or animal—apart, therefore, in such particular organism from the sympathetic nervous system, nothing lives, and with its death, the life of that organism, as an organic unit, ceases. The sympathetic nervous system, thus, represents the vital principle, or life, and, therefore, has vitalised, and continues to vitalise, every living thing, since the “dawn of organic life” on the globe, perpetuating life, or vitality, in continual succession, along the *lines of life*, throughout both the animal, and the vegetable kingdoms, meting out the span of existence of every living unit, and organism, and maintaining the perennial continuity of the life forms, which have peopled, do people, and will people it. Hence, apart from it, so far as the organic life of this planet is concerned, nothing lives, or can live, and to it all life is due, the everlasting, yet ever-varying, forms of life, evolving themselves according to its intrinsic methods of progress, and procedure, and taking their appropriate position, as links in *the great chain of life, and individual organic destiny*.

The germ, and sperm, protoplasm, or the primary parental elements, vitalised with the sympathetic dynamic

principle, or vital force, approach, merge, and continue the living characteristics of the parental sources from which they were shed, transmitting, from one generation, to another, in succession, the original life principle, to be clothed in organic form, according to environment, and preceding condition of life—"like producing like," and like, plus modification, producing like, plus modification, in endless succession, and increasing variety.

The sympathetic nervous system, so-called, therefore, becomes synonymous with every non-systemically innervated living structure, and is possessed of the dynamic powers of life, or the vital qualities, constituting that inscrutable entity, in its relationship to organic matter, and the succession of life forms. By it, every organic atom, or molecule, is brought into vital line, and continuity, in the formation of every living cell, or in the building up of every structure, and organ, of every living creature, for the preservation in health of that creature, with its specific characteristics, material, and dynamic, in order to maintain the great "sequence of events," involved in the great process of evolution.

These views necessitate a belief, in the parallelism, and convertibility, of the terms, sympathetic nervous system, and all varieties of cell, and fibre, structure, embraced within the economy of an organic body, other than those innervated by the systemic nervous system. From this, the further belief is necessarily deducible, that all living organic elements, or structures, are divisible into two categories, according to their manner of innervation, and that the many forms of structure known to anatomists, and histologists, are but names for the various modifications of nervine development, as they become evolved by increasing functional complexity, due to variation of environment, and continued elaboration of structure, and function, to meet increasing organic wants, and dynamic requirements.

Such a division of the textural elements of the most complicated living organism, simplifies the conception of its working, shows more clearly, and intelligibly, the interdependence, and co-ordination, of its various parts, and organs, and brings into relief the continuous "adaptation

of means to ends," in the various arrangements of parts, organs, and textures, which are to be met with along the *evolutionary way*, in individual organisms, as well as, at the various stages of racial development, and organic evolution, generally.

Life, thus, becomes the function, and indisputable attribute, of the sympathetic nervous system, all the non-systemically innervated textures composing its material basis, and all nervine activity, apart from the systemic, being its dynamic possession.

It may, further, be contended that the systemic nervous system itself is but an outgrowth from the sympathetic nervous system, and a specialisation, for particular purposes, in order to meet requirements which the generalised, organic, and dynamic, sympathetic arrangements, are unable, and unfitted, to meet, and, therefore, that the machinery of life belongs absolutely to the sympathetic nervous system, and is operated by that system, to satisfy the entire organic wants of every living organism, vegetable, and animal, invertebrate, and vertebrate, automatic, and reasoning.

Assorting the constituent textures of the body on the principle, that there are but two divisions possibly demonstrable, we are struck with the root observation, that the evolution of the embryo, must have a determining effect, in laying the foundation of the divisional distinction; and, from this point of view, we are warranted in taking for granted, that the original division of the ovum into ectoderm, mesoderm, and hypoderm, is responsible for the initiation of the developmental arrangements, whereby the differentiation is effected. Thus, the mesoderm, and hypoderm, may be regarded as the peculiar organic habitat of the sympathetic nervous system, with its formative machinery, material, and dynamic, while the ectoderm may, in like manner, be regarded as the organic matrix, from which the systemic nervous system is ultimately evolved, by the formative, and organising, energy, of the neighbouring sympathetic nervature, on the peculiar organic elements of that embryonic ectodermal area.

The sympathetic nervous system is, thus, constituted of, or claims as part of itself, the alimentary apparatus, the

blood circulatory machinery, the mechanism of nutrition of the non-systemically innervated textures, and the great lymph circulation, with the organs, and viscera, subservient to the purposes of organic life, and the various textures composing all of them. The systemic nervous system, must, therefore, be composed of all parts, and structures, unaccounted for in this list, and lays claim to its own particular structures, composed of the brain, spinal cord, and nerves, together with the muscles, tendons, and, to some extent, the bones, with, more or less, of the associated, and dovetailed, structures, uniting, and functionally associating, the two systems, in their combined work of maintaining the vital integrity of the organism, and superintending its life-work. It goes without saying, therefore, that all the above exists *latent* in the molecular constitution of the fecundated ovum, and but requires, for its evolution, the existence of certain conditions, supplied from parental sources, "ready to hand,"—nothing, here, being left to chance, or accident, but, on the contrary, everything, to the minutest requirement, material, and dynamic, being provided with unerring precision, as to time of doing, and sequence of formative result, with the consequence, that "like produces like," in accordance with the organic axiom, deduced by embryological science, from manifold observation, and supporting experimentation.

EXTRACT XXXIII. A.

ON THE DISTINCTNESS, AND RELATIONSHIPS, OF THE TWO NERVOUS SYSTEMS IN STRUCTURE, AND FUNCTION.

THAT the systemic nervous system, in whole, and in part, is anatomically, and histologically, distinct from, its surrounding, or, so-called, non-nervous, or sympathetically innervated, related textures, is true, must be accepted partially only, or to the extent that complete insulation, or distinctness, characterises only the parietal relationships of the completely developed textures, nervous, and non-nervous, thus leaving the neuronal, or nerve cell, dendritic processes, and the nerve terminal processes, or extensions, or the proximal, and distal, extremities, respectively, of the systemic nervous system, to commingle with, and merge in, its non-nervous, or sympathetically related, textures. Into this inner, and non-related, or distinct, anatomical nerve area, we contend, therefore, that, owing to this lateral insulation of the axonal fibres, no substance can enter, save by these proximal, or dendritic, processes, and that no substance can be exuded, or excreted, save at axonal process interruptions, and by the distal, or peripheral, nerve terminals, sensory, and motor ; from which it follows that all substances entering said systemic neuronal area must circulate, or grow, from its proximal, to its distal extremity, and be exuded, or shed, there, and that the nervous system, generally is dual, in structure, and function, we also assert—our reasons for making this assertion, however, we shall attempt to present in some detail.

This doctrine of neural duality, is by no means new, the division of the nervous system into systemic, and sympathetic, having been acknowledged for a somewhat long period by, anatomists, physiologists, and clinicians alike, in their treatment of the great subject of the nervous system. Anatomically regarded, the duality of the nervous system seems more apparent, than real; nevertheless, a well-marked individuality characterises the respective structures of the brain, cord, and nerves, of its systemic division, and the ganglionic developments, and connecting nervature, of its sympathetic division, which becomes more and more apparent, when subjected to physiological observation, and clinical experience, supplemented by pathological research. By the light shed from these various quarters, and focussed on discernment of this individuality, and duality, of structure, and function, we perceive that the systemic nervous system is related to the so-called non-nervous structures alone, which are concerned with the daily recurring volitional, and intellectual, necessities of life, and that the sympathetic nervous system, so called, is related to the non-nervous structures, and the passive, organic, or formative, functions, displayed in varying manner, and degree, throughout the entire chain of living creatures, vegetable, and animal, alike. The systemic nervous system displays its activity rhythmically, or by "fits and starts," according to, and synchronising mainly with, the earth's diurnal motion, the intervals of rest being utilised to repair waste, and renew energy, while the sympathetic displays a constant, if faintly intermittent, functional activity, in maintaining the continuity of organic molecular change, and exchange—the former, or systemic, acting only during periods of consciousness, while the latter, or sympathetic, acts continuously from the beginning to the end of the individual life, thus realising, in the economy of healthy organic life, the harmonious working of a dual organism, on the lines of the oft-quoted political parallel, or institution, an *imperium in imperio*.

Pathologically, the harmony, and success, of the working of this dual nerve economy is liable to disturbance in numberless ways, and to numberless degrees

of complexity, thus affording a kaleidoscopic vista of never-ending study to the exponents of clinical, and physiological, medicine. Paralysis, motor, and sensory, in all its degrees, illustrates the partial, or complete, breakdown of the systemic nerve organism, while necrosis, or gangrene, illustrates the breakdown of the sympathetic nerve organism, both breakdowns owing their origin to failure of their respective nerve structures, or of the supply of the proper nutritional, or materio-dynamic, elements, on which the continuity of life depends. Each occurs independently of the other, and runs a course, determined by its own structural, and functional, character, and relationships.

This deduction, and formulation, of the principles of duality, and individuality, of the nervous system, may be said to warrant the further deduction that, besides constituting the mainspring of vegetative, and animal, life, and supplying the energy for the maintenance of voluntary, and intellectual, activity, from its universal combined distribution, to the entire cell and fibre commonwealth of the body; it may be, in actuality, regarded, as not existing apart from, but, as actually constituting, that organic commonwealth of cell and fibre, and as acting, by, and through, it, in the performance of its manifold functions, in the manner, as it were, both of producer, and user, or as both citizen, and president, so to speak, of that commonwealth, in one. Each division of the nervous system exists, and acts, apart, or separately, in the performance of its peculiar, or individual, functions, but conjointly in certain communal nerve functions, such as the alimentary, and respiratory.

The sympathetic nerve cells, grow by kariokinetic division, and build up, through their growth, the whole, so called, non-nervous textures of the body, by a process of proliferation, which continues to make progress, or increase, until the attainment of adult age, after which it is reduced in proportions, but continues, to the degree, commensurate with, the maintenance of tissue renewal, and integrity; on the other hand, and in entire contrast to the sympathetic nerve cells, which are synonymous with the cells of the whole non-nervous structures of the

body, the systemic nerve cells are produced, *once for all*, in numbers, exactly in accordance with the permanent functional necessities of that system, and do not afterwards increase in number, nor can be renewed if destroyed. It may be said, in criticism of these statements, that the, hard and fast lines of neuro-systemic structural evolution do not allow of the great functional advancement achieved in the persons of individuals, of "light and leading," who have been, more or less, in evidence, in every age of the world's history, and whose systemic nerve structures must have been superiorly developed, in spite of the limitations of neuro-cellular, addition, and renewal; but in answer to this criticism, we would venture the opinion, that the difficulty involved may be quite satisfactorily met, by the ability, and power, of every systemic nerve cell, to develop new processes, *amæbally*, or by the strengthening, and lengthening, of those primarily developed; moreover, the effect of continuous, and systematic, exercise, within the bounds of physiological safety, is always productive of expansion of structure, and increase of functional energy—so we would account for the seeming contradictoriness of the above conditions, and statement, of facts, by adducing these physiological axioms, as quite sufficient to meet the difficulties.

The systemic nerve cells, and processes, are, necessarily, the structural products, and functional formative work, of the sympathetic nervature, and are dependent for their combined existence, on the nutritive materials provided by the activity of that nervature, from where its related hæmal vasculature, deposits the required pabulum, amid the delicate neuroglial fibro-cellular textures of brain, cord, and ganglia.

A systemic nerve cell, if once lost, is lost for ever, while a sympathetic nerve cell, if lost, can be renewed, or rather substituted, by proliferation from a neighbouring cell, so that the continuity of the bodily, so-called, non-nervous textures can be perpetually secured, and the integrity of the body, though paralysed, sustained, and made habitable to, it may be, an unclouded, and active, mind. In such a condition as that here described, moreover, we see plainly, also, the dual nature, and

functions, of even the systemic nervous system, in that while the control over voluntary muscular activity is lost, the work of the mind, or intellect, can be continued, it may be, with pleasure, and interest.

For the life, and growth, of the body, during its pre-natal existence, it is not necessary that there should be an actively working systemic nervous system, because an acephalic monster can be developed, and born, alive; we, however, would reserve, in such a case, the surmise, that the presence of, it may, or rather must, be, some of the basal, cerebral centres, and certainly all the cord, and nerves, with the exception of some of the cephalic, are essential to its evolution, and development—besides, it is most likely that the acephalic factors produced their effects, long after the inter-penetration of the foetal textures, by the systemic nerve elements, took place.

In the work of development, and organisation, of the embryo, in the growth of the foetus, in its attainment of the adult condition, and in the maintenance of what constitutes the remainder of the individual life, we claim, that the sympathetic nervature is everything, does everything, and supplies everything, for its own wants, besides producing for, and ministering to, every material want of the systemic nervous system, and maintaining the material, and functional, oneness, of the united organisms. There are, thus, only *two material entities* constituting the highest type of animal organism animated by, or with, that *immaterial ego*, which is the proud, and distinguishing, prerogative, and attribute, of, at least, every human creature.

We shall, therefore, express our strong desire that two distinguishing, and expressive, terms, should be adopted, and used, to express, in less cumbrous fashion, than we have been able to do, with those which have now come to our hand, to describe, so to speak, the *dual dynamico-materiality*, of man.

EXTRACT XXXIII. B.

ON WHAT DISTINCTNESS OF THE SYSTEMIC NERVOUS SYSTEM IMPLIES.

DISTINCTNESS of the systemic nervous system, within its organic textural surroundings, implies, amongst other things, only *comparative*, or *practical*, *distinctness*—for we are not warranted in making the term absolute—of its organised nervous texture, as well as of its lymph, or peri-nervine fluid, and hence the removal of the latter, from within the nervine precincts, without admixture with the surrounding systemic, or hæmal, lymph, is uniformly effected, save when the efferent nervature discharges its contents, fluid, and plastic, into the muscular areas, and substance, and thence into the systemic, or hæmal, lymph, circulation. This discharge, so long as the nervine lymph is maintained in a state of purity, chemical, and physiological, is accomplished, without pathological incident, so soon, however, as it betrays a departure from that condition, tell-tale sequences of morbid events, begin to manifest themselves, in accordance with the nature of the morbid interference, or diseased process, which often culminate in the production of a definite morbid condition, as it is known to the, diagnostician, and nosologist. To the keen observer, therefore, is thus afforded most valuable information, and circumstantial evidence, for his guidance, in the choice of treatment, as well as, for the satisfaction of his scientific *amour propre*.

The afferent, sensory, or cutaneous, peripheral nervature, possesses outlets, by which the nervine lymph, or

fluid, is thrown out of the system, without the possibility of its admixture, except in somewhat rare pathological states, with the systemic, or hæmal, lymph, or the blood circulation: diseases, therefore, occurring within this area, begin, and end, as purely nervine, and cutaneous morbid entities, being initiated, as a rule, by sepsis of the cerebro-spinal lymph, and closed by the excretion of the resulting bacterial organisms, with their resulting toxins, through the various cutaneous, and other nervine emunctories, where their nature can be read, in characters impressed on the implicated areas, by varying modes of eruption, and outfall disposals.

On the contrary, the efferent, or motor, nervature, terminating directly in the musculature of the body, throughout its entire extent, exudes, or excretes, into that musculature, the entire lymph, passed along its peri-neural inter-spaces, or lymph paths, which, in morbid conditions of that fluid, must necessitate the production of specific morbid effects, in the form of morbid entities, determined by the nature of the particular *materies morbi*, besides the occurrence of morbid processes in succession, throughout the entire "course of circulation," followed by the lethal, and malign, viri, and "sequences of events," characterising much of the disease incident to this *mixed* region, before elimination, or neutralisation, of the tainted neural lymph can be effected, by hæmal, or systemic, agencies.

As types of two classes of disease, thus arising, we would mention *Herpes Zoster*, and acute rheumatism—the former, representing a disease beginning, and terminating, with, and comprising the stages of invasion, occupation, and abandonment, of a limited portion of the neural, or cerebro-spinal, lymph, area, the latter representing, a more or less, wholesale invasion, and occupation, of the motor areas, together with the extra-nervine areas, to which it is related, and which lie between it and the systemic lymph circulation, along which combined tracts of circulation, morbid action may prevail, before the cessation of its symptoms can ensue, or its evil results subside.

This much applies to the lymph disposal, only in its aspect of distinctness, from the surrounding hæmal lymph

circulation, but does not embrace, that of the purely nerve structural aspect, of the subject of neuronal distinctness. This latter part of the subject may be described as illustrating, a distinctness of neural texture, from the surrounding non-neural related textures, of an even greater degree, inasmuch as the neuronal elements, being more plastic, or solid, than their surrounding lymph elements, do not lend themselves to capillary circulation, or disposal, except on certain definitely organised, or structural, lines of arrangement, to which they alone are subservient, and to which they, of purpose, lend themselves. Thus, the neuro-plasmic elements of the various neurons, after circulation through the containing tubules of the medullary, and axis cylinder, substances, respectively, furnish organisable materials capable of further organisation, to the various textures, in which they happen to terminate, by a final process of axonal division, or disintegration, and a cellular rearrangement of the, divided, or cast-off, materials, from which follows, a corresponding series of pathological manifestations, and morbid entities.

EXTRACT XXXIII. c.

ON WHAT THE DISTINCTNESS, AND RELATIONSHIPS, OF THE NERVOUS SYSTEMS LEAD TO.

WE have already said that the systemic nervous system, in whole, and in part, is anatomically, and histologically, distinct, from its surrounding non-nervous related textures, with the exception of where its dendritic, and terminal, extensions, commingle with, its inlet, and outlet, sympathetically innervated economy, in contradistinction to the intermediate complete insulation of the entire axonal fibres, of the systemic nervature. Into this inner, and non-related, or distinct, anatomical nerve area, we contend, therefore, that no substance can enter, save by the dendritic, or proximal processes, and that no substance can be excreted, save by the peripheral, or distal nerve terminals, sensory, and motor; from which it must follow, that all substance, entering and passing through, this intermediate nervine area, must circulate, from its proximal, to its distal extremity, and leave it there, and, therefore, must consist of neuronal pabulum, or nerve plasma only, and be obtained from the matrix of the neuroglia, by the nerve cell dendrons, and circulated to the peripheral extremities of the axons, by one continuous, and uninterrupted, system of circulation,—a system of circulation, which is *par excellence*, the innermost, and terminal, circulation, and which, in histologically ending, ministers to the growth of the non-nervous structures, with which it is distally related, on the completion of its intra-nervine course, by exudation through the entirety of the nerve terminals, into the matrix of the tissues, in

which they are developed, and whose innervation they simultaneously effect. Thus, the substance of the outer layers of the skin, with their local modifications, and appendages, the epithelial, and endothelial, surfaces of various membranes, the parenchyma of certain viscera, and the sarcous elements of the muscular structures, all benefit nutritionally, by the "cast-off," or excreted, plasma, of the systemic nervous system.

In its beginnings, and its endings, therefore, the systemic nervous system is structurally continuous with, its non-nervous, or sympathetically innervated surroundings, in virtue of which it is directly nourished by them, and in turn vitalises, and energises, them, at its distal termination. In passage through, or conveyance along, or amid, these structures, it, however, is completely separated, and insulated, from its surroundings, by the non-conducting, and insulating, textures, surrounding, and enclosing, its component cells, and fibres. These remarks apply to the systemic nervous system, although they apply, to some extent, also, to the sympathetic system, in its relationships, ganglionic, and neuro-fibral, to what, may be called, the quasi-nervous textures, which it innervates, and the maintenance of whose life is entirely due to it, as well as the non-nervous elements of the systemic nervous system, to which latter it is distributed as the *nervi nervorum*, which circumstance indicates, that the maintenance of the vitality of structure is essentially due, to the action of the sympathetic nerve energy, and plasma, and that this materio-dynamic combination suffices to maintain the life of structure, from its origin in the fecundated ovum, long antecedent to the development of the systemic nervous system, until its somatic death, which may be preceded by the virtual death, or functional disability, of the systemic nervous system.

We may regard it, we think, therefore, as axiomatic, that all merely vegetative, or animal, life, apart from the higher functional life maintained by organic forms, is due to, and maintained by, the action of sympathetic nerve energy on the elements of organic protoplasm, in the processes of living analysis and synthesis, which constitute the vital rôle of living matter.

The dual nature, and functions, of the systemic nervous system, we must, therefore, regard, as embodying principles of the deepest physiological and psychological importance. That a human being can live physiologically, and be dead physiologically at the same time, is a matter of everyday observation, and experience, in fact, it is the daily experience of all, during the condition known as sleep, and the experience of many, in certain pathological states, and is the outcome of the existence, in the sympathetico-systemic nervous system, of a dual control, and combined functional rôle, whereby the continuance of organic, and conscious, life, is made possible, secure, and lasting. The continuance of the dual control characterises the life of the healthy individual, while its lapse, in whole, or in part, indicates that disease, or disablement, exists, and unless removed, that the death of the part, or the whole, will inevitably follow. Moreover, we think that all living, or organised, matter, whether vegetable, or animal, *lives*, in consequence of being innervated, or vitalised, by what is equivalent to sympathetic nerve energy, which, in consequence, is *equivalent* to vital energy, or *life*. *This principle of life, regulating and inspiring*, so to speak, determines, and directs, the arrangement of inorganic matter, into the manifold forms of, living, or organic, matter, animal, and vegetable, and dominates, and maintains, a large proportion of the lower life forms of the globe, joining with, and merging in, the higher, or systemic nerve energy, in dominating, and maintaining, the highly organised remainder.

Nerve energy has many characteristics in common with electric, and other, forms of energy, but is endowed with many, other, and higher, characteristics, in virtue of which we are bound to recognise it as the highest form of energy observable by science, and a type, to which all the others point, and can be made to minister,—in fact, until consciousness, and mental operations, are at last displayed by it, and where it seems to enter on a process of still higher evolution, with relationships, which lose themselves in *apparent actuality*, and *non-exhaustion*, amid the realms of imagination, the regions of the unrevealed, and the absolutely mysterious ; but where, from its character, or

quality, of indestructibility, and increasing subtilty of mode of working, it may, nay must, still be able to minister to, and satisfy, the inherent "longings," and "clings," of humanity to the indefinite future, or the eternal. Here, however, we must resign the prosecution of the enquiry, in this direction, into the hands of the metaphysician, and those, whose peculiar function it is to bring themselves, and others, into intimate, relationship, and fellowship, with the "unseen, and eternal," with the strong hope that science, and religion, will ultimately, alike, benefit thereby, on the ground that *all knowledge*, belonging to the human family, is *one, and indivisible*, emanating from the same sources, and leading in the same directions, although, for the time being, these are *so seemingly divergent, contradictory, deviating, and multiplex*.

Life, moreover, regarded from the point of view of its origin, and evolution, may scientifically be said, to be never-ending, and we would, also, say that it is without beginning, save with regard to its original creation, inasmuch, as, since that creation, it has continued without break, or failure, each successive unit, of every successive generation of living things, being united by life, to its immediate predecessors, by the indestructible bonds of living energy, operating on, and through, organised material. Thus, also, life is perpetuated, in its higher forms, by the projection into immediate contiguity, and resultant continuity, of two vivified particles of organic protoplasm, the vital amalgamation of which, constitutes the commencement of another generation, and the starting point of a new being. Towards this was contributed, from the two parent sources, a quantity, or proportion, of *living matter*, the union of which, continues, in undying continuity, the life of the parents, and the antecedent line of pre-existent living forms, constituting our, human, and ante-human, lineage—likewise, will the continuance of the operation of the same laws, along the same organic lines, ensure the, propagation, and continuance, of the human, and other, species, *ad infinitum*, or until the required conditions no longer exist.

Life, vital force, and sympathetic nerve energy, thus viewed, are one. and the same, in nature, and attributes,

and suffice, for the conversion of the inorganic matter of the earth's crust, into the living forms, with which we are familiar, by a process of living inter-penetration, and vivification, the organic results of which, are abundantly observable, although yet entirely mysterious. The beginning, the continuance, and the ending, of the process, can be seen in endless variety, all around us, yet the most acute observation, the most subtle experimentation, and the most logical reasoning, of the physicist, and physiologist, have hitherto failed to do more, than maintain a perennial interest, in the enthralling, and transcendental, subject. Not physically, but physiologically, and psychologically, regarded, however, we would seem "almost on the brink" of projecting our *inner vision* across the gulf, that separates the "seen, and temporal," from the "unseen, and eternal"; this gulf, by the united light of science, the telescopic powers of reason, the innate yearnings of the human heart, and the "overflow" of revelation, lying evident, in full perspective, as "one expanse" of gradation, and rising perfection of evolutionary result, without a break, or the suspicion of a solution of continuity, in its entire proportions. Thus, the finite, and temporal, *can be seen* to merge in, and to constitute a portion, for the time being, of, the infinite, and eternal, whose horizons recede and widen, in proportion as the range of vision, and conception, increase, and the "adjustment of sight" becomes more perfect, showing space, time, and eternity, commingling, and inseparably blending, in one continuous expanse of unbroken vision, pointing onwards, and outwards, to the arrival of that period, when the "former shall be no more," or shall exist as mere evolutionary incidents, in "the story of creation," and cosmic growth.

EXTRACT XXXIV. A.

ON THE DIVISION OF THE "NEURAL WORK" AS
EXEMPLIFIED IN "THE NERVOUS SYSTEM" IN
ITS RESPECTIVE PARTS OF SYMPATHETIC AND
SYSTEMIC.

IN a previous treatment of this subject, we endeavoured to make plain the respective rôles played by the two systems. Further study of the subject, however, compels us to amplify these remarks, in order to make plainer our views on the subject, and to afford, to a fuller extent, the materials necessary, for laying the foundation of a more exact neuro-psychology, than we have yet been able to formulate. We would, in beginning these supplementary statements, again bespeak, for the sympathetic division of the nervous system, a larger place in the scientific field of neurological phenomena, every day brought into research prominence, by the army of investigators, now spread over, we may say, the whole world, and a fuller treatment, than it has yet obtained, so that its proper value, to the science and art of medicine, may be obtained, as we are firmly convinced that this can only be attended by unmixed advantage, both to the progress of abstract science, and the enlargement of our powers, of healing and amelioration.

All vegetable life is due to a vital mechanism, actuated by the equivalent of that neuro-dynamic agency, which is entrusted with the administration of sympathetic nerve energy, and the maintenance of lower animal life exclusively, and which shares, with the systemic nervous system, the maintenance of life, throughout the higher animal world, and, therefore, in man, *par excellence*.

The exclusive, or independent, exercise of sympathetic nerve energy, being, thus, sufficient to maintain in being the larger half of the life of the globe—of the vegetable entirely, and of the lower animal, a great proportion—besides entering into the dual nervine control of the higher animal forms of life.

In this alliance of sympathetic and systemic methods of innervation, we see the greatest triumph of dynamic combination, and control, that is to be found throughout the whole range of biological physics, and recognise the use, for combined biological purposes, of two of the most marvellously constructed generators and distributors of energy anywhere observable by man throughout nature.

The sympathetic nervous system, in man, is capable of, and responsible for, acting alone, for, roughly speaking, a third of his lifetime, and for the remaining two-thirds, of uniting with the systemic nervous system, in maintaining the continuance of the vital energies of his body generally, and in aiding the systemic system in the dual control of conscious life and work.

The work of the sympathetic system, is not, and cannot be, interfered with, by the systemic, save by violence, the alliance being so entirely and consistently dependent, upon the principle of mutual respect, that no wanton interference is permitted with the prerogatives of either system, on the part of the other, unless when pathological agencies find access and produce confusion.

What may be called the organic work of the living body, is entirely within the administrative jurisdiction of sympathetic nerve influence, and is accomplished, so long as the conditions of life hold out unimpaired, and so long as the material supplies are forthcoming, and the preliminary, and terminal, somatic conditions, are maintained by the systemic nervature.

The latter, the systemic nervature, is responsible for the choice and supply of the proper elements of food, and their proper quantity, besides the supervising of the economy of excretion, and the maintaining of a strict watch on the disposal of the effete products, resulting from the work of the former. The mutual working of the two systems must, therefore, be secured in detail,

in order to the maintaining of the functional integrity, and the consequent freedom from material clogging, and implied organic friction, on which the possession of health depends.

The basis of life, and health, therefore, must be sought for, first, in that portion of the body, beholden to the sympathetic nervous system for material, and dynamic, support, and administration, and in this, when the conditions required by that system are maintained, or restored, by the aid of art, or nature, the *status quo ante* is regained, and health again established. In doing so, we find that the materials necessary for nutrition must properly, and regularly, be supplied, and that the economy of nutrition, must be maintained aright, when it will follow that life, and health, will be the inevitable consequences, and the attainment of the usual physiological balance, the necessary result.

We are warranted, we think, in asserting that disease can never enter into the living economy, unless by the faulty working of the two great biological factors, the material and dynamic, and their two supervising nervatures; the primal necessity will, therefore, arise, whenever a disease problem presents itself for consideration, for obtaining a clear understanding, of where that disease has commenced, and at which point in the sympathetic, or systemic, nervatures, it has taken origin, in order, that treatment should be adopted on scientific lines, and carried out with a clinical consistency, flowing from a full knowledge of cause and effect, and a full appreciation of the sequence of morbid phenomena, in order to secure the re-establishment of the physiological régime, and the, consequent, restoration of health.

The field of vital action is as wide as life itself, and includes, contiguously, and contemporaneously, examples of physiological, and pathological, methods of procedure; so that, throughout the whole extent of animated nature, we see the advent, and departure, of living forms, in every instant of time. We subject its problems to investigation, and are compelled to acknowledge that health, disease, and death, are essential component parts of a great whole; and that what our very finite powers of observa-

tion, and abilities to affect beneficially their incidence, in the everyday life, health, and death, of man, will enable us to achieve, must be diligently sought after, or out, and perfected, along these essential, determining, and *limiting* lines. Roughly speaking, the life of man has not materially changed, in length or duration, since we have any consistent, or definite, statements, on the subject, left us—the "patriarchal" lives, reckonable on a lunar basis, being no exception to the rule. It is doubtful, therefore, whether even science, the most modern, will be able to satisfy man to a *much greater* extent, than have the many futile attempts of the searchers after the *elixir vitæ*, and other "will o' the wisps," resulted in. While science must have its limitations, as the greatest human factor, in the great philanthropic work of prolonging the span, and making more perfect the conditions, of the life, vouchsafed to the race, it, nevertheless, behoves every thinking man, to "leave not a stone unturned" to secure, as far as possible, all that is attainable in this direction, so that, at the least, the rate of progress of true civilisation, may be given fresh impetus, and increased volume, of forward movement.

The life of man being the outcome of the dual working of the two great nervous systems, in which the vital energies reside, and of which life, so called, is dynamically composed, in which they are generated, and by which they are distributed, it behoves, that the reason, and other mental faculties, dominating the systemic nervous system, should be properly used, in conjunction with the automatically acting, sympathetically inspired nervous system, in order that the vital output should reach its highest possible limit. Reason, instinct, and the so-called *innate* directing faculties, of the living human organism, must be trained to combined action, and must be controlled, on lines consistent with the maintenance of life at its highest level of attainment, in order that the greatest perfection of working, and the highest condition of health, should result.

Dual control may, thus, result in the highest possible form of corporeal, material, and functional, health, and the accomplishment of the greatest amount of work, with

the least expenditure of energy, and the highest attainment of speed, consistent with safety to the machine, and the realisation of the intention of its existence.

The two nervous systems are arranged, within the body, in such a way, as to work in the manner here attempted to be described, either singly, or dually, as required, and are surrounded, on all sides, by the so-called non-nervous textures of the body, through which they operate, in performing their various functions, and which, in turn, they energise, and keep in material and dynamic, union and cohesion, for the accomplishment of individual, and communal organic ends and purposes, and organismal necessities.

For these high purposes, the two systems, are evolved on two essentially different lines, the one, the sympathetic, beginning with the dawn of embryonic life, and perpetuated from pre-existent, or parent, sources, and the other, the systemic following, when the conditions of life of the embryo transcend the powers of its more rudimentary being, and working, and call for a still further evolution of the conditions of life, if the organism is to continue to be further evolved, and its organic destiny attained.

The stages of evolution, or developmental progress, thus exemplified by the embryo, and ranging from the unicellular, to the multicellular, group themselves along the lines of cell proliferation, and cell organisation, for growing, and increasing, functional purposes, tissue formation, and visceral development, for special purposes, the growth of limbs, and consciously exercised motive power. The systemic system, it is thus seen, comes on the developmental scene, when the sympathetic has laid the foundation for, and used up much of its evolutionary energy, and material, in the formation of an incipient ultra-sympathetic nervous system, destined to blossom into the great psychological instrument of brain, cord, and nerves, through which, dead matter can be made the instrument of, consciousness, intelligence, and morality, to raise man to a height of destiny not yet attained by his lower relations, in the scale of life, and being.

Inside the so-called non-nervous structures of the body, insulated, and encased, by many a layer of non-conducting

tissue, surrounded by a fluid medium, in which it floats, safe from shock, and friction, the nervous system, in its dual formation, and unal functional rôle, vitalises, energises, and controls, the living and working of the body, deputing the various departments of that work, to appropriate portions of that system, in combination with appropriate portions of its non-nervous structures, and controlling the whole, for the communal purposes of the entire organism.

While the insulation, and bufferage, provided by the non-nervous elements, in this great pan-neuro-systemic organisation, is of the most complete, and effective, character, it may be further claimed for it that it provides, simultaneously, a neuro-distributive medium equally omnipresent, and effective, in the many nervine procedures of reception and transmission, on the one hand, and of resolution, and transmission, on the other, or, in other words, of the receipt of sensory, and the transmission of motor, nerve impulses.

Nerve energy, here, may, in a sense, be regarded as, the product of nervine secretory activity, and due to the physiological receipt, independent production, and storage, within the intra-cellular bodies, known as nucleoli, one of whose functions, or, it may be, whose sole function, is, the manipulation, so to speak, of nerve energy. This most transcendental subject, however, we have elsewhere dealt with—it seems, therefore, unnecessary to deal further with it here, beyond saying, that we have not, so far, had reason to change our opinions thereon.

Nerve energy cannot be produced, received, stored, or distributed, by any other structure, than the nervous, and it cannot be, by the nervous structure, unless that structure be insulated and protected by meninges, and their equivalent continuations, neither can it be, unless these meninges, and their continuations, are, in turn, surrounded by a layer, or layers, of cerebro-spinal fluid, the presence of the latter, being essential for the passage of nerve energy, both from without inwards, in answer to stimuli, and from within outwards, as impulse, in the most special, and specific, physiological manner. That each division, of the great nervous system, can produce,

receive, store, and distribute, its own specific nerve energy, there cannot be the slightest doubt, as daily, physiological, and clinical, experience, and observation, abundantly prove; and that there is a balanced reciprocity in all the daily, and hourly working, of the two systems, there is, equally, not the slightest doubt; it is, therefore, essential, at all times, to bear this in mind, and to be prepared to recognise its existence, and act in accordance with, its requirements, whenever called upon—as, we may be every day, in such ailments as, the now fashionable one, of neurasthenia.

In this disease, if we are really entitled to call it a disease, the exhaustion of nerve energy may be dual, that is, it may involve the generating powers of both systems, in which case appeals must be made to both, and the requisite restorative means applied to each, or both; in a word, the proper nutrition of both systems must be arrived at, the dormant powers of their associated musculatures roused, and their mobile abilities renewed, all which, bespeaks the adoption of physiologically indicated means, as the rational, and scientific, way, to clear up the situation; proper food, successful digestion, free circulation, and exact assimilation, must be supplied, and sought after, by consulting the sympathetic nervous system; while freedom from care and worry, judicious exercise of both musculatures, fresh air, and all hygienic adjuncts, must be supplied, to meet the wants of the systemic nervature and musculature; and the continuance, and regulation, of these, according to the necessities of the individual case, must be persevered in, in order to the maintenance of health when re-established; all which, looks most simple, while, at the same time, it requires the use of the highest powers of discrimination and tact on the part of the physician. Neurasthenia, being essentially a condition of health resulting from modern forms of civilisation, and requiring for its treatment the prescription, more especially, of rational preventive measures, with the adoption of the above-mentioned curative agencies, and manner of life, so soon as it can be said to have begun, it behoves the observant physician, as well as the relatives of its subject, to be on the watch,

lest it be allowed to progress beyond the bounds of cure, or even relief.

That part of the organism, controlled by the sympathetic nervature, will generally require the first attention, and, it may be, that that attention will be all that is required to obviate the involvement of the systemically innervated structures, and the more pronounced evolution of the neurasthenic phenomena.

The physiological relationships of the two neuro-musculatures are based, to a very large extent, on the principle of reciprocity, the stock of nerve energy, possessed by the entire combined nervatures, being common and available for the work of either, or both, and, thus can be drawn upon by either, or both, so long as the histological continuity of the combined sympathetico-systemic nerve media subsist; any perversion of this principle of reciprocity may, therefore, lead to most serious inco-ordination, and neuro-muscular confusion, as well as intellectual disturbance, when connected with the highest cerebral "centres." Nutrition, the great central function of the sympathetic nervature, is essential for every detail of vital activity, both of its own structures, and those of the systemic nervature; it, therefore, is essential for the neuro-muscular activities of the whole body, and the maintenance of nerve energy, which may be considered, in most essential respects, as equivalent to life itself.

It may be assumed, as a principle, that every conscious feeling, physiological and pathological, is realised by the systemic nervature alone, and that, when such conscious feeling emanates primarily from the sympathetic nervature, it does not become realisable by the systemic sensory nervature, until it has passed outside of the sympathetic nervature, the latter system, on no occasion, appealing to the systemic sensorium, until it passes its impulses into the related ganglia, and their systemic neural communications, the exact histological appreciation of which constitutes a clinical asset, of the greatest value, in both diagnosis and treatment. Diseases of the viscera, especially, afford examples of the truth of these remarks, and it cannot be gainsaid that, when the structures, and functional connections, of the two nervatures, are better

understood, and the principle of sympathetico-systemic nervine reciprocity, more fully appreciated, that a long step forward in scientific medicine, will have been taken, and a way opened up to cope with the complicated processes of disease, by which our powers for good will be largely increased.

We may regard it as axiomatic, that every medical appeal must be made to the nervous system, and that the appeal must be made to that system, in both its unal, and dual, capacities, in order that it should not miss being successful. It must, also, be at all times remembered, that the key to every vital position, structural and functional, is to be found within the nervous system, in either its material, or dynamic, condition, or both, and that the dual control of all nervine action, must ever be present in the mind, in seeking a practical solution of any problem, involving the nervous system—and, it may be, asked, pertinently, what disease does not involve the nervous system, directly, or indirectly?

The distinction, and the reciprocal relationships, of the two nervous systems, suggest the conviction, that a most profound biological deduction, is warranted, therefore, viz. that there are two organisms within the human personality innervated by the sympathetic, and systemic, nervatures, respectively, and that man is made up of a material, and dynamic, being, living, and acting, consciously, and unconsciously, by virtue of this dual innervation, which is resolvable into its separate parts, by influences, inimical to the continuance of the dual existence, or life.

Death, therefore, constitutes the natural termination to this dual existence, releasing the dynamic, from the material, being, and allowing their entering into new combinations, to continue the cycle of change, and evolution, in endless progression, and absolute order, along the lines of continuity of force, and matter, respectively. Death in reality, therefore, can only be considered, as the biological continuance of, the dynamic or vital, principle, in combination with new evolutionary factors, of a metaphysical order, and the physical return, of the material components of the organism to the matrix, whence they were originally derived.

Science, and revelation, here, mutually bear witness to the existence of the same great truth, viz. that life is continuous, or immortal, and that, therefore, the present life is but a prelude to, and a preparation for, a life, whose end is dynamically impossible and unthinkable, and whose evolution will continue "throughout the endless ages of eternity." We, therefore, hope, that the exponents of the great truths, both of science, and revelation, will become, more and more, impressed with the cogency, and reasonableness, of this conclusion, and will rise to a true appreciation of the sublime helpfulness obtainable from it, when regarded from the respective, standpoints of lay and clerical teachings. A bond of union, between these two great schools of thought, and action, will thus be gained, whereby a feeling of mutual respect will be created, and joint action made possible, in the regions, of human necessity, and divine charity.

If the law or process of evolution be applicable to the proper understanding of physical and biological progress, then, without unduly burdening it or straining it, we feel that applying it to the apprehension of the "progress of things" intellectual and spiritual, we are warranted in the belief, that we are likely to increase our realisation, and extend the horizon of our inner vision, "of things not seen and eternal," and thus of being able, beginning with things provable by the senses and the reason, to undertake the transcendental task of penetrating the far outside spaces of the universe, and the far distant past and future of time, so as, in some infinitesimal degree, to make out the why and wherefore of our existence, and to locate to some extent our whereabouts, and the character of the efforts required to place ourselves inside the area intended for our reception, continued growth, and expansion.

Spiritualism, in the highest sense of the word, and materialism, viewed from such a standpoint, cease to be antagonistic, and merge, as fragments of the same great body of revealed and scientific fact, into the "weft and woof" of universal truth, in the inseparable bonds of indivisible continuity.

In the growth, culmination, decay, and dissolution of the human body, we witness the union and disunion of a

dynamic, or spiritual, entity, with a material organism, which it animates and keeps alive for a brief period, in virtue of the play of sympathetic innervation alone in its earliest stages, but ultimately, in conjunction with systemic innervation, when the attributes of intelligence and moral sense become superadded and evolved into more or less perfection of development, under which all the best attributes of humanity appear and fructify, when the inevitable dissolution of the bonds between substance and energy takes place, and new resolutions become effected, whereby the reign of evolutionary law and progress are maintained, and everlasting existence secured. Every human body thus contains two beings, separable only by death, and each possessing an individuality, the one terminable in its character and individuality by death, and the other continuous in its individuality, unitable to other dynamic media, and capable of development *ad infinitum*, *aut vitam aut culpam*, and, it may be, retrogression and reversion.

The material body is innervated and maintained mainly by the sympathetic nervous system. We say mainly, because the innervation is dual, and the immaterial, or dynamic, portion is innervated by the systemic nervous system, that is, so far as a *dynamic body* can be said to be innervated, and when innervation ceases, new affinities must determine the character of the future existence of the two portions, so soon as their dissolution becomes effected.

EXTRACT XXXIV. B.

ON THE COMBINATION OF SYMPATHETIC AND SYSTEMIC MUSCULAR INNERVATION.

THAT the sympathetic nervous system is possessed besides a musculature of what is equivalent to one, *i.e.* a contractile mechanism, whereby it can effect the shortening and lengthening, or regulation, of certain organic textures, is a belief which, more and more, grows in strength upon us as we succeed in differentiating it in structure and function from the proper musculo-nervous system. Thus, the contractile mechanism, by which the shrinkage or contraction and relaxation of the perineo-scrotal textures is effected, seems to be repeated, wherever the phenomena of rapid cutaneous shortening and lengthening have to be accomplished, as for instance in the orbits, without the presence or aid of muscular fibre, and where necessarily a pseudo-muscular fibre is innervated by the sympathetic nervature ; and that this belief is well founded we are now fully convinced, and we would observe that such contractile movements are apparent when the systemic nervous system is entirely detached and insulated from the sympathetic nervous system, as in sleep and in some forms of paralysis, when vaso-motor phenomena generally, and cutaneous transpiration and perspiration phenomena are determined and regulated necessarily by the sympathetic nervature, through the contractile agencies resident in the structures concerned ; but whether the principle of a dual control could be admitted here it is premature to say, further than that it is highly probable. The cutaneous musculature, apart from such sub-cutaneous muscular developments

as the *platysma myoides*, we think, can only be innervated by the sympathetic, inasmuch as we find it quite impossible for instance, voluntarily to produce the conditions known as "*cutis anserina*," or the feeling of "streams of cold water running down the back," or that weird feeling of the "hair standing on end," or the wave-like feeling or formication engendered by the action of a cold current or draught of air. If these statements be well founded, as we think they are, it will at once become apparent that a very large functional neuro-muscular rôle belongs to the sympathetic nervous system—in fact, it would appear that virtually the whole functions of organic life, and the greater part of those of reproduction, are under the entire control of the sympathetic system, and are only slightly affected by voluntary interference, or systemic nerve influence, hence the maintenance of the continuity of the entire vital processes during unconsciousness or sleep. Thus, the processes of alimentation, digestion, absorption, circulation, respiration, assimilation, metabolism, secretion, and excretion, can be, and are effected, without voluntary interference or control, while the processes involved in ovulation and embryonic development are entirely due to sympathetic innervation and vitalisation, and quite unaffected, except it may be in that remarkable, if somewhat doubtful, occurrence of "maternal impressions," by influences emanating from the maternal and passing to the offspring's systemic nervation.

Tissues composed of "elastic fibres," so called, the vaso-motor musculature of vessels, blood, and lymphatic and ducts, the muscular coat of the alimentary canal, and unstriped muscular structures generally, all respond to the innervating influence of the sympathetic system, and are entirely amenable to its controlling power; a provision for a dually innervated and controlled organism, the wisdom of which is only too apparent, and the physiological purposes of which are rewarded by a rigorous adherence to the "plans of nature," for the uninterrupted accomplishment of growth and nutrition, and vital operations generally. The sympathetic nervous system may, therefore, be regarded as responsible for the guidance of the performance of all neuro-muscular phenomena, save

those of voluntary origin and of purely neural phenomena, save those of intellect and will, or cerebation proper ; its enormous physiological importance thus can scarcely be overestimated, and the necessity for its more exhaustive study becomes more and more clamant. The histological connections of the two nervous systems, the systemic and the sympathetic, are well, if not completely, known, the "*rami communicantes*" of the systemic penetrating into every section of the sympathetic, and effecting a more or less complete amalgamation of the two—whether, however, these "*rami communicantes*" contain motor and sensory elements in equal or varying proportions, has not yet been determined. We are, therefore, at liberty to infer that both elements enter and leave the histological combination in physiologically balanced ratio, and that the exchange of systemic and sympathetic nerve energy respectively is maintained, in virtue of this histological arrangement, at neutral and non-explosive rate. The normal working of the combination is characterised by an almost complete absence of consciousness, on the part of the cerebro-spinal centres, of the various steps and stages of that work, the whole being effected without "let or hindrance," or apparent friction, amongst the agents supervising it, the sympathetic neuro-musculature being alone sufficient to meet all emergencies. When, however, any element of discord or friction enters into the working of these dual elements, a consciousness of its presence is at once the result, through the sensory fibres of the "*rami communicantes*," which consciousness so rouses the *vis medicatrix naturæ*, that she, if it be slight and easily removable, adopts the requisite means for its removal, or, if not, "calls aloud" to the "sleeping partner" for assistance, through intensification of the sensory disturbance and unmistakable pains.

EXTRACT XXXIV. c.

ON THE PRINCIPLE OF RECIPROCITY BETWEEN THE SYMPATHETIC AND SYSTEMIC NERVOUS SYSTEMS.

WE have already endeavoured to make clear that the nervous system of man is dual, in anatomical structure, in functional control of the working of the physiological life of his organs and textures, and in the determination of the destiny of his component parts, physical and metaphysical, material and immaterial.

These nervous systems are evolved in succession, the sympathetic first and the systemic second, from the unicellular organism called the fecundated ovum, the first, or sympathetic, being, in turn, instrumental in evolving the second, or systemic. They each, we have seen, while retaining their respective nervine individualities, act and react on each other, and perform their individual functions in the economy of the body generally, while they unite in the performance of the "thousand and one" common functions, in the bonds of a common origin, and to meet the necessities of a common organism, for common purposes, to the end that one great common organic object may be attained.

This principle of dual control, within the physiological working of the human organism, necessitates the existence of a "treaty of reciprocity," so to speak, between the two systems, determines the limits of individual freedom of working and administration within the limits of the common organism, and prescribes the occasions on which joint action is necessary to accomplish common ends. The importance of such a provision in the dual working

of such a complex organism as the human body, it is impossible to overestimate, inasmuch as at every pathological "turn of events" we are brought face to face with a violation of that treaty, and cannot see the restoration of physiological order, until we and the *vis medicatrix naturæ* have succeeded in restoring the *status quo ante*.

To illustrate the truth of these remarks, let us take one conspicuous example, which may be accepted as typical, viz. the great function of nutrition. In this the systemic nervous system, by virtue of its possession of the senses of taste, smell, sight, and touch, etc., and the faculty of reason, determines what is best for the nutrition of the body which it innervates, and supplies the requisite—not unfortunately without mistakes—materials, to the waiting and ready sympathetically innervated musculature of the post-pharynx, which at once, and without option, transmits them to the all but entire control of its associated sympathetically innervated, digestive, assimilative, and eliminatory textures and organs, for distributive disposal and final elimination. If this can be accomplished without "let or hindrance," the systemic system is rewarded for its implicit trust in its co-treaty power, and co-partner by the nutritive and eliminatory work involved being done to its entire satisfaction and abiding comfort; if, however, as is always possible in the best-regulated labour compacts, elements of friction and disturbance have been unfortunately allowed to enter, a period of discomfort and mutual distrust and recrimination between the two systems ensues, until the *vis medicatrix* succeeds in clearing the total dual commonwealth of every cause of discomposure, and in restoring its lost physiological order. It is nothing less than astonishing to observe with what long-suffering, and infinite disposition to meet its obligations, the sympathetic system labours, and with what success it accomplishes its unaided, and often thwarted, labours, when called upon to prepare from the most unpromising and heterogeneous materials the plasmic elements of nutrition, and to distribute them unerringly to the expectant tissues and organs of the body. It is, moreover, not less astonishing to observe with what precision and executionary ability it seizes, in exchange for its new tissue elements, the

worn-out and effete materials which have "borne the brunt" of organic tear and wear, and which now must be removed, to prevent auto-toxis, and "make way" for a new molecular distribution of nutritive plasma. All which is accomplished by the unaided efforts of organic textures innervated by the sympathetic system, and, very slightly only, supplemented by the systemic, and mainly at the points of exit of the excretory organs only—or where the conjoint action of the two systems is necessary for the orderly and unopposed operation of the eliminatory machinery, and the communal recognition of mutual obligation. In the mutual discharge of the communal functions of the two nervatures, a somewhat elaborate set of mutually understood signs and warnings are constantly in use by them, a true knowledge of which constitutes a not unimportant part of human education, and power to meet the functional emergencies and ever-recurrent necessities of everyday life, and which may "make or mar," to a considerable extent, the sum of human happiness, as well as of bodily comfort and health.

The clinical bearings of this latter fact, that the two nervatures maintain their frequent union of function, by means of mutually understood signs, and also become a physiological instrument, which, rightly used, may be fraught with great therapeutic power, in the hands of the observant and resourceful physician, when engaged in the routine of his daily work, and in estimating the nature, and strength, of the pathological factors to which he is opposed, are obvious.

As the systemic nervous system somewhat suddenly, and precipitately, resigns its burden to the care of its nervine colleague, the sympathetic, at the entrance of the alimentary canal, so does the sympathetic resign its burden, to be finally disposed of by its reasoning and alert partner, the systemic, and, if there should be any failure to understand, or appreciate, the language of the signs, by the latter, or any inability to meet the obligations, then the blame must be apportioned to the latter, and the way to prevent any recurrence of such a contingency must be sought for in the rectification of its intrinsic faults, by the application of appropriate remedies.

The resignation of systemic nerve control of functional activity, which, again, characterises the onset of sleep, is so imperceptible as to have absolutely baffled every attempt of consciousness to appreciate it, the sway of the sympathetic nervous system being substituted, for that of the systemic, so silently, so to speak, and completely, as not to arrest the *already* slumbering attention.

Moreover, the appreciation of the subjective feelings, or "calls of nature," of hunger and thirst, by the systemic nervous system, is of such constant and unvarying occurrence, as to give rise to nothing more than a routine feeling of attention, which is satisfied, or answered, when all that is necessary to appease them has been supplied to the oro-gastric organs.

EXTRACT XXXV.

ON NERVINE SECRETION AND EXCRETION.

THE brain, cord, and ganglia may be compared with, and described as, a Great Glandular Organ. It has been said that "the brain secretes," that "it secretes thought and nerve force," and in a functional sense this may be regarded as true. In quite another sense, however, we wish, for purposes of comparison, merely to describe shortly how it may be compared with a glandular organ, in order to make more clear and apprehensible some of the heterodox views, which are so freely advanced by us in these pages.

That portion of the central systemic nervous structures composed of brain, cord, and ganglia, has conveyed to, and distributed without and within it, a very large blood supply, the outer portion of the vasculature of which is developed within the texture known as the *pia mater*, while the inner, or proper, blood plasma distributing vasculature is developed in the neuroglial matrix of these central neuro-genetic masses. The former vasculature, the outer, or true *pia mater*, with its extensions, or inflections, known as the choroid plexuses, secretes or exudes the fluid known by the name of the cerebro-spinal lymph, the latter, or inner, exudes, or extravasates, the substance known as the neuroglia, both parts of this great circulation thus performing functions equivalent to the blood circulations of organs known as true glands—the secretion of the outer *pia mater* being fluid, that of the neuroglial vasculature viscous. Except in so-called ductless glands, every secretion becomes an excretion,

and has provided for its removal, or elimination, an excretory duct or ducts; therefore, in instituting this comparison we have not been unmindful of the requirements of the situation in this direction, inasmuch as no glandular organ within the human organism can compare with it in the extent and variety of its excretory facilities. Thus, we claim that special, as well as general, facilities, are provided for these excretory purposes almost everywhere around the periphery of the entire systemic nervous system, as well as by every nerve terminal within the internal structures of the body, so that this fluid can never—everything being physiologically correct and sound—become a source of danger from over-pressure, or fail to afford relief when pressure becomes dangerous, from outside or inside, hydrostatic or hydro-dynamic, circumstances. These excretionary provisions consist—we may again say to ensure familiarity with the subject—of the following amongst others, viz. the olfactory mucosa, the tonsillo-glosso-pharyngeal mucosa, and the coccygeal gland, excretory mechanisms, along with the peripheral nerve terminal developments, and sweat glands, as well as the motor nerve and plates, and sarcolemmar sheaths, with their tendonous, periosteal, synovial, and osseous continuations and connected systemic lymphatics.

The quantity of this fluid, for the time being, must necessarily depend on the exigencies of the intra-systemic nervine pressure, being regulated by the vaso-motor agencies of the pial vasculature, so that a state of hydrostatic equipoise can be maintained within, without, and throughout, the entire nerve developments of the body, by a continuity of circulatory facilities, and excretory agencies, of an absolutely complete, and effective, character. Inside this regulated, soft, and fluid, barricade, safe from the concussion and friction of the outer world, the great nerve organism is “at liberty,” and can, therefore, perform its varied and manifold secretory, and other functions, tranquilly, and rhythmically, in accordance with physiological, and psychological, law and order.

The comparison would not be complete were we to omit that great nervine secretion which takes place in

the neuroglial matrix, where every nerve cell, composing the systemic nerve cell commonwealth, secretes its nutritive plasma, and excretes it by growth along its axonal fibre, to supply, on the one hand, the elements of the cuticular investment of the body, and, on the other, the nutritive pabulum of the sarcous discs of its voluntary musculature. These two secretions become ultimately, by a continuity of intra-nervine circulatory disposal, in their respective intra-nervine functional rôles, a common but dual excretion, fluid or plastic, according to its manners and methods of final disposal, and is eliminated like other effete, or dead, products.

EXTRACT XXXVI.

ON THE DEVELOPMENT OF SOME OF THE ORGANS OF SENSE, AND THE MANNER OF ARRANGEMENT AND DISTRIBUTION OF THE CEREBRAL AND SPINAL MENINGES AT THE OPENINGS OF EXIT OF THE CEREBRO-SPINAL CAVITY.

It may now, we are convinced, be accepted as true that the systemic nervous system is enclosed by the meninges, or their equivalents, throughout its entire extent, both within and without the cerebro-spinal cavity, and that the nervous system, and its meningeal, or equivalent containing textures, are exactly conterminous, and parallel, in extent, and distribution. That being so, we may take it that the developing nerve textures are provided with, or push before them, their meningeal, or peripheral, coverings, to the limit of their extensions, where they remain a permanent means of protection, support, and inhibition. Accordingly, therefore, to the nature of the particular nerve, whether it be special, or general, we find a particular arrangement, and adaptation, of the meninges, in their peripheral development, to suit its particular circumstances and function. Thus, the spinal nerves, and the cephalic nerves, with the exceptions of the second, and first, pairs, in passing out of the cerebro-spinal cavity simply push before them, on their exit from it, an extension, or projection, of the various meningeal folds with which they are immediately surrounded, and carry them to their respective terminations in unbroken continuity, and distinctiveness of texture, as well as, with their inter-spaces, patent, and capable of circulating their contained cerebro-spinal fluid or lymph. The

second and first pairs of cephalic nerves, being exceptions from this manner of meningeal accompaniment, require a few words of special reference. Instead of beginning their course of development directly from the cerebral periphery, they are projected as proper cerebral textures, or processes, for a considerable distance along the base of the brain, before the nerves proper, to which these textures, or processes, lead, become evolved, and organised. In the early neuro-vesicular stage of embryonic growth, these two pairs of special sense nerves originate, as projections, or swellings, of the nascent fore-brain, and surround themselves with continuations of the nascent meninges, as they

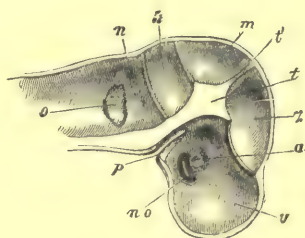


FIG. 129.—LONGITUDINAL SECTION THROUGH THE HEAD OF AN EMBRYO OF FOUR WEEKS. 1^o. (From Kölliker.)

z, anterior encephalic vesicle, cerebral portion; *z*, interbrain; *m*, midbrain; *h*, cerebellum; *n*, medulla oblongata; *no* and *a*, optic vesicle; *o*, auditory depression; *t*, centre of basi-cranial flexure; *t'*, lateral and hinder parts of tentorium; *p*, the fold of epiblast which forms the hypophysis cerebri.

leave the developing cranial cavity, and so dispose of these meningeal textures that they become part and parcel of the proper sense organs; almost the same may be said of the auditory division of the fifth pair.

The vital process of developmental adaptation of these meningeal textures to the requirements of sense organs, is one of the transcendental examples of nature's methods of turning the common into the uncommon, and of utilising the ordinary, and immediately available, formative materials, for the accomplishment, or production, of extraordinary organic purposes and ends. (On this subject we claim that another *Bridgewater Treatise* might be written, and occasion for literary inspiration, and graphic delineation, amply provided for, in their highest flights.)

The optic vesicular (Fig. 129) enlargements of the

fore-brain, in their early development and evolution, enwrap themselves in their meningeal coverings, and project themselves, through interstices in the enclosing cephalic wall, into the forming orbital recesses, where they blossom into the future eyes stage by stage, until they culminate in the formation of the most wonderful sense organs known to biological science, in its entire survey of animated nature. In the process of transformation undergone in the adaptation, and conversion, of the meningeal coverings of the optic processes for structural purposes, we see the *dura mater* converted into the sclerotic coat, and the *arachno-pia mater* into the choroid coat, of the eye, and made suitably supporting, and nutritional, media, for its accommodation, and growth, as well as for the yielding of liquid materials, suitable for the formation, and continual renewal, of its vitreous and aqueous humours, from the inter-meningeal spaces, and their contained cerebro-spinal fluid. Simultaneously with this meningeal transformation take place the growth, and evolution, of the true nervine textural elements of the optic organism, and the complete dove-tailing of its nervous, and non-nervous, elements, whereby its receptivity of, and susceptibility to, the influence of light energy are finally obtained, together with the meso-blastic interpolation, or grafting, of the crystalline lens, and the formative completion of the resulting structure as an organ of sight.

The evidences of design so abundantly observed in all these developmental phenomena, and the unerring adaptation of means to ends displayed in the formative processes referred to, along with the absolutely equipoised, and effective, exercise of vital energy, truly reveal that the "law of evolution" is but a scientifically convenient name for an intelligence, and power, which it is impossible, and would be puerile, to attempt to ignore. Moreover, we discover here that a great evolutionary event, or perhaps the greatest in the evolutionary history of man, has been wrought, by which the *inner man* is enabled to look literally out at, and is looked in upon by, the *outer world*, and has revealed to him the great facts of the existence of two entities, viz. the ego and the non-ego, together with much that goes to make up the sum of human knowledge.

The first pair of cephalic nerves (Fig. 130), in like manner, originate from hollow extensions of the fore-brain, which terminate over the cribriform plates of the ethmoid bone, where they carry with them their meningeal coverings, separated by their intervening spaces, and fluid contents, the latter of which they discharge, or distil, into the nasal

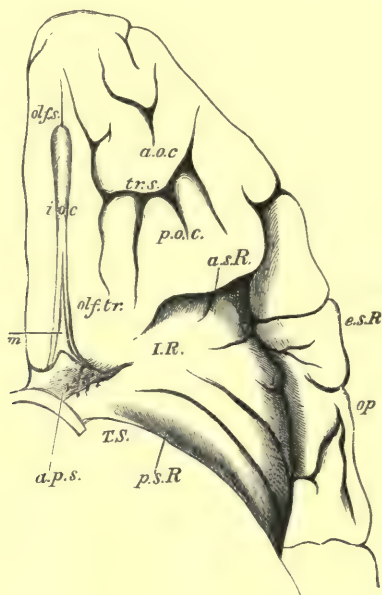


FIG. 130.—ORBITAL SURFACE OF THE FRONTAL LOBE, AND ISLAND OF REIL. Natural size. (Turner.)

The island (*I.R.*) is exposed by removal of the apex of the temporo sphenoidal lobe. *T.S.*, cut ridge of this lobe; *a.p.s.*, anterior perforated space; *a.s.R.*, *p.s.R.*, anterior and posterior limiting sulci of the island; *op*, operculum of the island. *tr.s.*, tri-radiate sulcus; *i.o.c.*, *a.o.c.*, and *p.o.c.*, internal, anterior, and posterior orbital convolutions; *olf.s.*, end of the olfactory sulcus; *olf.tr.*, olfactory tract, bifurcating behind into the two roots inner and outer; *m*, middle root or tuber olfactorium.

passages through the glandular mechanisms of their lining mucosa, thus allowing of their performing the double functions of sense organs and lymph excretory agencies. This mention of nasal cerebro-spinal lymph excretion brings to our mind that we might here take another opportunity of enumerating the various channels of exit, or excretion, with which we have had occasion to deal in our inconsecutive treatment of the great subject of cerebro-spinal lymph disposal. Besides the nasal excretion of cerebro-spinal

lymph, we have had to mention, or describe, in more or less full detail, excretion from the glandular organs, the pituitary and pineal, of the third ventricle, which may be looked upon as the great excretory mechanism of the central brain structures, and, consequently, the most elaborate and intrinsically perfect system of vital residuum disposal to be discovered in a survey of the whole system; excretion from the spinal inter-meningeal spaces through their continuation along the *filum terminale*, the coccygeal gland, *bladder* or *lymph heart*, and an outflow series of channels, or ducts, terminating in, and around, the anal orifice of the alimentary canal, where they have been provided in the metamorphic materials laid down on the differentiation of the neurenteric canal; excretion by the skin through its sweat glands—truly a vast excretory area—excretion by, and through, the optic apparatuses, excretion by, and through, the auditory organisms *via* the Eustachian tubes, and into the spinal intra-dural matrix by the ductus; excretion through the pneumogastrics into all the viscera, with which they are in textural, or histological, relationship, and excretion by all the fibres of communication distributed to the sympathetic nervous system, with secondary excretion therefrom into the parenchyma of organs, into the great serous cavities, through the mucous surfaces, and into the recesses of the cellular, and connective tissues, as well as excretion by the motor nervature into the muscular tissues, tendons, periosteal textures, joint cavities, and bones, their central marrow, and the vascular textures developed therein, by which final neuro-systemic excretion is effected through neuro-systemic excretory agencies.

EXTRACT XXXVII.

ON THE RELATIVE PROPORTIONS OF THE GREY AND WHITE MATTER OF THE BRAIN AND CORD, AND THE MANNER OF UNION BETWEEN THE SENSORY AND MOTOR AND THE PSYCHIC NEURONS.

THE true proportions, relatively to each other, of the white and grey matter, as they are distributed throughout the three great central nerve organisms, the brain, cord, and ganglia, is a question of the greatest interest to the neurologist, but necessarily a question that must remain unanswered, inasmuch as the proportion must necessarily differ, in each human organism, at every particular phase of its life; it must, therefore, be regarded as varying, as much as any other morphological feature, or element, varies, in the various members, or units, of the human race. It seems quite true, however, that the value placed by science on a relatively high proportion of grey matter to white is founded on truth, deducible from anatomical and histological data. Thus, we may take it that anatomy teaches that the grey matter is dependent for the possession of its distinguishing characteristic of colour on a vital, and material, difference in structure between it and the white, and that the particular, or peculiar, pigmentation of the grey matter would itself suggest, that the active blood circulation must be the determining agency, on account of the presence in its blood-conveyed materials of pigmentary matter just suitable for conferring the particular shade of colouring possessed by the grey matter: this suggestion, moreover, would seem to be warranted also from the process of

blood change going on within the elements of that fluid as it passes through the peculiar chemico-physical changes characteristic of the *pia mater* metabolism, consisting mainly of the separation from the blood stream of cerebro-spinal lymph, to maintain the circulation of that fluid throughout its whole extent, and the deposition of glial substance within the neuroglial matrix, for the sustenance of the nerve units, or neurons, with the necessary, and the consequent, intensification of the colouring of the remainder, or residuum, of the blood substance, and hence the conferring on that remainder of the peculiar shade so markedly belonging to the "grey matter." That colour is neither in the overlying, or inter-penetrating, cerebro-spinal fluid, the proper neuronal structures, nor the glial substance on which the neurons are supported; it must, therefore, be intimately connected with the capillary blood vasculature, and its contents, as it passes through it the residual blood material of the pial circulation.

This colour is only observed where nerve cell growth is in progress, or where the neurons arise as cells from the neuroglial matrix, or feltage, and pass out into the white substance as axonal processes, to be connected with other nerve cells, or to be distributed as nerve terminals to skin or muscle, according as they are sensory or motor. Those cells, therefore, which are not terminal, sensory, or motor, nerve cells, must end individually by passing into, or through, other nerve cells, which must also necessarily be surrounded by a matrix of grey substance, and thereafter end in sensory or motor terminals, or in turn pass through further grey matter extensions until they finally reach their terminal stage of distribution in, or to, sensory or motor textures; from which it becomes obvious that a large proportion of the cerebral neurons must begin and end histologically and functionally there, *i.e.* within the proper structural matrix of the cerebrum, and, therefore, that they do not necessarily directly pass out into the peripheral regions of the systemic nervous system. The widely distributed areas of grey substance to be seen overlying and inter-penetrating that organ, therefore, thus assume the character of great

internally working neural structural necessities, when we consider that perhaps the greater part of cerebration, conscious and unconscious, is confined within the precincts of the brain proper, beginning and ending there without necessarily disturbing, to an appreciable extent, the outer nervine calm, or making much, if any, impression on memory. All this vast region of *non-peripherally related neuronal activity* pertains to the constant ordinary, as well as the higher intellectual and transcendental, regions of man's everyday life and experience, and constitutes a great portion of "the weft and the woof" of the inner life fabric, and determines whether it will be perishing, or lasting, as a contribution to the daily and hourly record of individual effort.

In this highest sphere of psychological activity we enter *in reality* the region of human anatomy, where material mechanism is constructed for the performance of functions of a materio-dynamic character, the quality of which can only be dimly appreciated by the exercise of those inherent or innate hyper- or meta-physical human qualities which more or less pervade the records of the highest types of materio-dynamic philosophy and spiritual insight. From this point of view it becomes evident that "a whole cosmos" of human experience is confined within the *non-peripherally related*, or the *highest cerebral centres*, where the higher sensory centres, and the great motor centres, are co-related with, but prohibited from entering, the great mental areas, where the ego, the seat of consciousness and abstract thinking and reasoning, abides, protected, if not free, from friction with the external world, and at liberty solitarily to cogitate, associate, and perchance commingle in activity, with materio-dynamic and spiritual existences on lines altogether transcendental, but nevertheless appreciable by the intellect, or perhaps visible to the "mind's eye," and defined more or less clearly by the "exponents of things spiritual"—as seen in what they have handed down to us in the pages of revelation, and the works of "light and leading" which from time to time have been "given to the world" by the highest types of humanity. The mind of man has thus an indefinitely large cerebral materio-dynamic field

in which to grow and unfold itself, and to lay the foundation of a spiritual being, or existence, which will ultimately outgrow and overshadow its material environment, and on the dissolution of which it will be absolutely capable of a separate existence, and continued development. The certainty of this is absolute, and incapable of disproof, being founded on dynamic law, which is as absolutely unalterable and inexorable in its operation as any of the eternal laws of nature, or of truth, known to science, or to revelation, so far as the human intellect can realise them. The material basis, or cerebral matrix, in which the higher intellectual operations of the brain are carried on, may, roughly speaking, be taken as composed of those neurons which arise from, and end in, the grey matter of the brain, cortical and central, and which do not, therefore, *directly* subserve the materio-dynamic purposes of the peripherally related cerebro-spinal, or central, nervous system. It is thus a region of cerebral structure which does not lend itself well experimentally to the exact psychological disentanglement of its local histological elements into their various functional areas according to the character of their respective mental rôles in the working of the material and immaterial organisms, so to speak, of the mind; or, in other words, the experimental methods of physiological interpretation, to which our present knowledge of the nervous system and its working owes so much for its advancement, cannot be made serviceable when applied to the elucidation of the laws of the genesis and evolution of mental phenomena from brain matrix and mental dynamics.

The vast congeries of cerebral neurons situated above and beyond the points of origin and the "spheres of influence" of the histologically connected, and functionally co-related, systemic nerve centres, represent the areas of cerebral matrix whose functions are purely or peculiarly intellectual, and therefore entirely occupied with the highest ranges of human work and destiny. Within this uppermost and innermost cerebral region there can be no doubt that the same physiological laws of metabolism, the same reign of material law and order, but a much higher range of dynamic work or activity, prevails,

to the end that hereby man may attain a condition of mental and moral advancement, to which there is no approach elsewhere observable throughout the whole kingdom of animated nature.

These cerebral areas of intellectualism would seem to be confined within the structures situated above the *tentorium cerebelli*, or in that region of the great central nervous system situated within the anterior, middle, and posterior cephalic or brain spaces, where also the great connecting centres of sensory and motor nervine activities become linked up, united to, and blended with those of mind proper.

The manner of the union of these kindred, but distinctive nerve elements, however, is a subject too subtle and transcendental to do more than mention; nevertheless, we are persuaded, from the analogies which are observable in somewhat kindred relationships, that materio-dynamic conditions regulate and determine it, on the same consummate physiological, and we may add, psychological, lines, that can be so lucidly traced through great areas of that complex and far-reaching subject of brain and nerve anatomy. Within the cerebrum, material agencies and mechanisms co-exist, capable of acting singly or conjointly, accordingly as the mental and bodily materio-dynamic conditions require and necessitate, and accordingly as they are actuated by altogether central, peripheral, or combined nerve energy; besides modes of nervine activity which are more or less constantly manifested, consisting of purely mental, sensory, and motor impulses, each, it may be, occurring independently by itself, or in conjunction with, or succession to, others. Much discussion of the subject of neuronal growth, and nerve cell disposition of axis-cylinder substance, has been indulged in by neurologists, but it cannot yet be said that more than tentative opinion prevails on it; thus, we may suppose that strands of axis-cylinder substance, emanating from the first, or earliest, spongioblastic cortical ranges of the ectoderm or the most remote cortical nerve cells, and from the most distal and profound ranges of centrally originating cells, within the domain of the mentally endowed areas of the succeeding embryonic

layers of grey substance, without being broken up, are received, rearranged, and passed on by the second, to the next interpolated cells, to be finally distributed, in terminal arborisations, peripherally, or in continued successional cell progress, until at last they pass into, and become structurally incorporated with, the cutaneous and skeletal textures, to which the systemic nervature is finally distributed. Be that as it may, the manner of union between successive neurons, through axis-cylinder substance agency, allows of independent activity of each nerve cell unit, and secures its contribution of individual functional work to the sum of communal neuronal work, and the credit of the entire cerebro-spinal neuro-dynamic industry.

The relationships between the absolutely mental neurons, the cerebro-spinal, sensory, and motor neurons, and the co-related sympathetic nervature, are of the most profoundly intricate and, so to speak, remote character, as well as of the most delicate nature structurally, so that the most powerful microscopes fail to penetrate their inner mode of working, and the most finished modes of experimentation fail to elicit more than the faintest flashes of intelligible meaning and information; here, therefore, a great deal must needs be taken for granted, and a scientific faith must needs be exercised, which will place the votaries of science on a platform almost identical with that held by the exponents of revelation and theology.

As bearing on the understanding of the working of the neuro-dynamic machinery of the highest, or mental, nerve centres, we would quote, as a quite relevant speculation, founded on a species of textural elimination of the various cerebral contents, a study of this series called: "In search for the home of the ego," in which it is claimed that the *totality* of the nucleoli of what we would now call the *mental*, or *psychic*, *nerve cells* constitutes that "home," or the particular, or peculiar, habitat of the mind.

The *mental nerve cells*, or *mind occupied neurons*, of the cortical and central grey substance of the cerebrum, end in the central, or upper, cerebro-spinal, sensory, and

motor areas, and therefore issue as proper cerebro-spinal neurons, with their nerve terminal expansions situated at various levels, from the cephalic base to the posterior extremity of the spinal cord.

The peculiar local distribution and textural arrangement and relationships of the grey and white substances of the

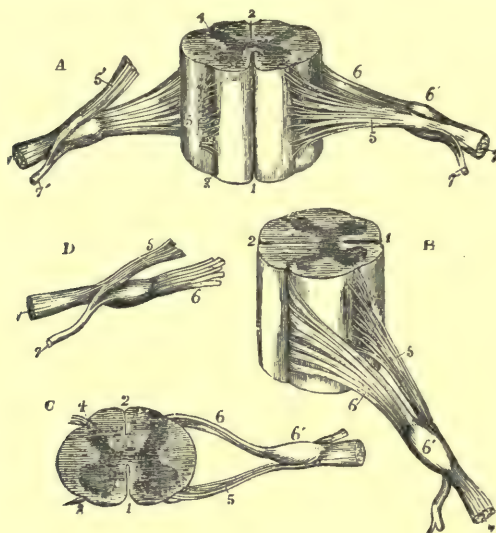


FIG. 131.—DIFFERENT VIEWS OF A PORTION OF THE SPINAL CORD FROM THE CERVICAL REGION WITH THE ROOTS OF THE NERVES. Slightly enlarged. (Allen Thomson.)

In A, the anterior surface of the specimen is shown, the anterior nerve-root of the right side having been divided; in B, a view of the right side is given; in C, the upper surface is shown; in D, the nerve roots and ganglion are shown from below. 1, the anterior median fissure; 2, posterior median fissure; 3, antero-lateral impression, over which the bundles of the anterior nerve-root are seen to spread (this impression is too distinct in the figure); 4, postero-lateral groove into which the bundles of the posterior root are seen to sink; 5, anterior root; 5', in A, the anterior root divided and turned upwards; 6, the posterior root, the fibres of which pass into the ganglion, 6'; 7, the united or compound nerve; 7', the posterior primary branch, seen in A and D to be derived in part from the anterior and in part from the posterior root.

brain and cord respectively undergo great changes both within and without the skull, these relationships, in regard to peripheral and central, or superficial and deep layering, undergoing a complete textural metastasis on the elimination of the purely mental structural elements, whereby, after passing through the medulla oblongata, the grey matter assumes a united bicrescentic (Fig. 131), or H shape, surrounded by the white matter, in well-defined

columns of co-related histological extensions of the upper cerebro-spinal axons, and the succeeding spinal axons, sensory and motor, as they are given off or received by the various spinal nerve trunks; the gross quantity of the grey matter undergoing increase where the great plexuses are formed for the innervation of the upper and lower limbs respectively, and where necessarily the glial substance must be present in increased quantity to meet the nutritional wants of the increased neuronal expenditure, sensory and motor, or cutaneous and muscular. The contrasting arrangements as to position of the intra-cephalic and intra-spinal (see Fig. 131) grey and white matter are very striking, and seem to suggest a "natural selection" of a profound character, as being the determining influence—such that the true neuronal, or nerve cell, areas require an environment of the most protected and insulated character possible, and that nature procured these wherever she could consistently with material necessity and functional advantage. Thus, immediately under the protective influence of the skull meninges and the cerebro-spinal fluid, as well as under the more resistant local structural developments and arrangements of the white, or connecting and conducting, substance of the brain, and within a complete encasement of resistant white matter in the spinal cord, nature has sought to procure protection and support, for perhaps the most invaluable, as well as the most highly functioned and important structures of the body, and so has once more displayed a marvellous adaptation of means to ends, and an example of design which calls for recognition, as one of the most outstanding, and embryonically the latest, in the whole category of such "natural wonders."

EXTRACT XXXVIII. A.

ON SOME VIEWS OF THE STRUCTURE AND FUNCTIONS OF THE SYMPATHETIC NERVOUS SYSTEM—IN- CLUDING NERVINE NUTRITION AND NERVE FORCE EQUILIBRATION.

WE have already stated that this system—the sympathetic or its equivalent—exists in all living structures, and that the energy generated by it is equivalent to *vital energy*, and in fact constitutes *life*, as displayed in all living organised textures, whether animal or vegetable. In vegetable, and in the lower forms of animal structure, we have not yet succeeded in determining the method of production, nor in fully displaying the channels, or fibres, along which this energy travels from the producing to the energised, or innervated, textures, yet we feel warranted in claiming that such energy does travel, or circulate, in definite lines throughout and within the limits of every such organic form or texture, in virtue of which that organic form or texture lives and has its being.

It may well be that the most skilful dissection, the most scientific use of reagents, and the most adept application of the highest powers of our microscopic aids, have hitherto failed in enabling us to trace the inner workings of this most inscrutable system in the cryptic regions of almost homogeneous living textures, and non-differentiated structural elements, in its maintenance of life, and regulation of the processes of metabolic change and exchange, *for* does not the great “Secret of life” itself lie here? If, however, our views on the subject can be widened by one hair’s-breadth, or made more definite, it behoves us not to rest content

within our present "range of vision," but to take the required step forward into the dimness of the unexplored.

In taking this step, and peering round us for a glimpse of any definite structure, or structures, which can or may perchance be utilised by this sympathetic, or life maintaining, nervous system, for carrying out its fundamentally important vital work, we have been struck with one outstanding universally present fact, viz. the presence, in overwhelming profusion, of a minute "structural element," *the cell*, and its contained nucleus and nucleolus inter-penetrating, in fact, constituting the structure of all organised structures, including the systemic nervous system, and variously known, according to the particular texture in which it is observed, as "proper organic" cell, connective tissue cell, and in fact every special cell,—apart from systemic nerve cell—wherever cell developments occur throughout the manifold textures and viscera of the organised body; it may, by the processes of elimination and combination, therefore, be claimed that herein, and hereby, the *problems of living matter* are being exhibited and exemplified or wrought out. This universally distributed minute structural element, we cannot help thinking, is the required structural medium through which sympathetic nerve force or vital energy is generated and distributed to living tissue, or organic matter; and that, while it no doubt is inextricably bound up with the more highly developed and functioned systemic nervous system, it is alone responsible for the maintenance of life and the supervision of the great functions of nutrition, growth, and the "continuance of the species." Thus, all involuntary movement, much of the so-called automatic action of the more highly developed textural elements of animal life, and all the purely vital activities of the animal and vegetable worlds, may be claimed as *absolutely due to sympathetic nerve influence*, generated in and radiated from the true, or specific, nerve elements properly belonging to that system.

Thus, the sympathetic nervous system may be said to energise all living organic substances, morpious and amorphous, in proportion to their degree of development, textural differentiation and vital requirements, and

according to their importance in the economy of the particular animal, or vegetable, organism that may happen to be the subject of observation.

Viewed thus, we may take it that the sympathetic nervous system is, *in reality*, structurally composed of every cell and connective fibre, forming the organised and innervated body, with their contained nuclear and nucleolar developments, or that the sympathetic energy, or life, is generated and distributed through their instrumentality by the genetic and radiating powers of the nuclei and nucleoli, and if this be so, we may further conclude that the sympathetic nervous system, so called, must have the further function, in analogy to the systemic nervous system, of *distributing* by its cell processes—after having secreted—*nutritive plasma*, as well as *energy*, to *every texture* with which it is in functional relationship.

The *function of nutrition* would thus become *entirely a nervous function*, every cell *secreting* from its surrounding blood-borne organic plasma through its wall, or by some of its processes, the necessary pabulum for its own maintenance, as well as that of its contained nuclei and nucleoli and related organic texture, or cells, and *excreting* by others of its fibrous processes, or through its wall, its effete materials into the surrounding organic matrix, to be removed by the various lymphatic agencies with which it is so abundantly supplied, and by, or through, the free surfaces of the coverings and the linings of the spaces and inter-spaces with which it is surrounded and whence it is directly removed. Therefore, every cell being a living unit, and living in virtue of its histological connection with, and innervation by, nerve structure and force, it follows that nerve texture and nerve energy must regulate and sustain the vital processes of nutrition, growth, and repair, from their inception in the gastro-intestinal canal, until their termination and disintegration and excretion by an unbroken series of circulatory acts, following each other in regular and unbroken succession, and once more illustrating the truth of our assertion: *circulatio circulatiorum, omnia circulatio*. Consequently nutrition, apart from its purely chemico-metabolic aspects, is a physical process dependent on nerve circulatory agencies, and

occupies organically the gap existing between the termination of the hæmal circulatory economy, on the one hand, and the beginning of the lymphatic collecting mechanism and circulation on the other. A metabolic "dumping ground," so to speak, being thus provided for both the incoming, or nutritive, and the outgoing, or effete, circulatory materials.

Nutrition, thus carried on, secures an atoxic, or non-autotoxic, condition of the pabulum supplied to the various textures nourished, inasmuch as the effete and toxic materials of the disintegrating textures are moved on and eliminated from them by, and before, the inflow of the fresh, or substitutive, material with which they are replaced—the one continuous circulatory movement sufficing for the necessities of the processes of disintegration and integration of the tissue involved in every, even molecular, act of nutrition.

Nutrition, consequently, may be regarded as the process of organisation in more or less permanent form, or the reorganisation of organic, or organisable, materials to meet the losses and fill up the vacua dependent on disintegration, and the wasting effects of "tear and wear." The first nutritive act of every organic unit must, therefore, date from, or coincide with, the earliest period of independent organic existence, and be dependent upon the selective and integrative operation of sympathetic nerve energy or organisable matter, by and through the inherited or transmitted sympathetic, or vital, nerve energy perpetuated in the fecundated ovum and kariokineted cell bodies.

Every cell must thus be looked upon as embodying the *principle of life*, and capable of sustaining a separate existence, in virtue of its being vitalised and sustained by its inherent and transmitted sympathetic nerve energy; its parentage and environment determining whether its life-work is to be individual or communal.

The sympathetic nervous system, of all the systemic nervous system bearing animal creation, must, consequently, be regarded as composed of every non-systemic nerve cell within the individual animal, and, therefore, that it must operate through and by these cells in the performance of all organic operations concerned in the

nutrition, growth, and cell life-work generally of each individual animal ; in other words, the sympathetic nervous system must be regarded as co-extensive with the living fibro-cellular structures of the animal body, whose individual cell vital energy it supplies, and whose united cell life-work it directs in the performance of organic function, for the accomplishment of the ends necessitated by its environment, and its destined purpose in the execution and economy of "nature's plan." The vital physics involved in the performing of sympathetic nerve functions illustrate the continuation in every living organism of the great process of circulation within the domain of nutritive action, and displays that process reduced to the disposal of atomic quantities, or proportions, in the "give and take," the integration, and disintegration ; the synthesis and analysis continually occurring in living tissue—one atom following another, and one replacing another, as the chemico-physical processes of life and vital atomic friction determine in the kaleidoscopic arrangements and re-arrangements of living matter.

Moreover, that vital force, or energy, which constitutes *life*, animal and vegetable alike, circulates through fibrous media and along atomic lines, provided by the ultimate atomic, or molecular, disposition of vitally disposed matter, amid the profuse, but ordered, array of the cell textures of organic tissues. Circulation, on definite lines, and along definite paths, thus characterises the movements of both living matter and vital energy in the process of nutrition in the maintenance of the individual cell life, as well as in the communal arrangement and collective working of the cells, in organised groups, as individual plants and animals, as, for example, in the amœboid mono-cellular organism, or the primal organised unit.

The normal, or perfect, physiological working of this law of circulation, must, therefore, be regarded as the *sine qua non* of health, and as requisite for enabling both the cell unit and the cell combination to perform the peculiar and intrinsic work, for which it and they are respectively adapted, and called upon by nature to execute. Any disturbance of this circulation must, in like manner, be attended by pathological consequences, of

a magnitude in proportion to the extent of that disturbance, and ranging, it may be, from a wholesale, or *en masse* degree, to an atomic, or infinitesimal, fraction.

The sympathetic nervous system thus, being co-extensive or synonymous with the whole structures of organic life, evolves from itself, as its highest or crowning example and stretch of functional activity, the systemic nervous system, to which it delegates the performance of those higher nervine functions which, in the higher animal forms, are super-imposed on those belonging to and characterising merely organic life. The connection, histological and functional, between the system is, therefore, one of continuity and inter-dependence, so intimate and co-ordinate that the one vitality or life animates the whole organism, while departmentally is delegated to each of the nervous systems duties peculiar to each, and capable of being performed by it alone—between these two departments of special nervine work, however, are neutral or dual areas in the nervine work, contributed to by both systems, in which each can substitute to a limited extent the other—thus the innervation of the abdominal viscera of the organs of circulation and respiration may be contributed, to some extent, by both systems, the one aiding, or supplementing, the other, when called upon to do so, under certain circumstances.

In relation to this doctrine of reciprocity, or dual control, between the sympathetic and systemic nervatures, the view might reasonably be advanced that under certain circumstances, in which the genesis of nerve energy is defective in the one or the other, energy can be transferred from the one to the other, in order to the insurance of continuity of function in the whole area innervated by both. Systemic nerve cells and centres and sympathetic ganglia may, therefore, be regarded as magazines or accumulators, as well as producers and transmitters, of nerve energy, and the performers of the very vital function of *equilibration of nerve, or vital, energy* throughout the whole nerve commonwealth, and related so-called non-nervous elements.

Equilibration of nerve, or vital, energy is a nervine function of the very greatest importance in every dually

innervated body, but becomes of paramount importance in the human body, where nervine agency is in evidence infinitely beyond the proportions existing in any of the lower animals, in which its production and conservation seldom reach the degree of explosive dimensions frequently attained in man.

We thus realise the value, to some extent, of the combined evolutionary continuity and distinctness, structural and functional, characterising the development and working of the two nervous systems, and the security that it affords against the occurrence of the explosions or "nerve storms," so familiar to the clinical observer, by the allowance of "points of exit" for pent-up nerve energy, whereby its escape may be effected along secure and inhibited channels into the peripheral regions of the general nervature, without the occurrence of cataclysmic or disastrous consequences; hence the attainment of nervine equilibration, or the measured production and distribution of nerve or vital energy, is secured or made possible throughout the entire dual nervatures by dynamic discharges into the less, or faintly, nervous connective structural elements to which they are distributed.

Faultily effected nervine equilibration, from whatever cause and to whatever degree, must always, therefore, rank as a proportionately more likely occurrence in man than in his nearest neighbours in the animal scale, and rationally devised measures of prevention must consequently be adopted in order to neutralise, or prevent it.

Such diseases as epilepsy, spasm, etc., are relatively more frequent in the human species than in the lower animals, and we conclude that the reason for this is to be found here; we, therefore, bespeak a more profound consideration of the problems of nerve force production, storage, and distribution, with the involved principles of nerve force equilibration, in order that the whole subject should be raised to a higher and more scientific platform, than it has hitherto occupied in applied medicine.

Equilibrium, in its etymology, signifies an equipoised or balanced state of things, and is applicable to conditions of rest and motion of simple and complex bodies alike, as well as to states of static and dynamic existence of

individual organised structures and of whole organisms. It therefore may be regarded as the condition to be sought after, whenever a disturbance of organ, or function, ensues from any cause throughout our own organism, and when our scientific knowledge is appealed to to prescribe the means of its re-attainment in others, the importance of its practical and utilitarian bearings will thus at once appear. Equilibrium, in the highly complex organism of man, is a matter over which nature fortunately watches with great care, and usually, if left alone, is quite able unaided, except by passive submission, to maintain and to retain, by virtue of her application of the *vis medicatrix*, to the right place and at the right time ; it behoves us, therefore, at all times, except when obstacles or impossibilities are placed in her way, and the removal of these is then dictated, to trust and dutifully aid her in her beneficent and often ill-requited work.

On a little thought and consideration of the subject of want of equilibrium, as it concerns and flows out of the conditions surrounding man, it will become obvious that it may make itself apparent and have its inception in any, or all, aspects of his being—*i.e.* physical, mental, or moral ; and that, therefore, its re-attainment by the *vis medicatrix nature* has at times to be aided and supplemented by the *forces of civilisation* known as medicine, law, and divinity, although, that these are unfortunately sometimes ineffectual as aids, from the want of rational and concerted application, is only too obvious an experience. The application by nature of her *vis medicatrix*, therefore, requires the rational and concerted use of *every* means provided by civilisation, in order that she may be able to place the human species on the high platform of moral, mental, and physical health, to which it is on non-utopian lines entitled to be placed, and which the whole history of the race up till now proves that it is longing for, if not always striving after. Disturbance of physical equilibrium in the individual organism may be universal, or local, may involve a system or systems, a viscus, organ, or tissue, and, therefore, may be felt as a disease, only faintly appreciated, or pass altogether unobserved, according to its extent and incidence. Thus, it may involve

the fluids of the body, and be felt wherever these fluids, or such part of them as is affected, penetrate ; if it involves the nervous system it is felt generally, or locally, according to which of its textures or enclosing elements happens to be implicated ; if it affects a viscus, or organ, it is felt throughout that viscus or organ, and within the radius of neighbouring parts included in its range of influence ; or if it affects an organic structure only, then it is realised only within the confines of that organic structure, or, at the most, within a very limited area. This being so, we need scarcely say that the scientific and practical bearings of the subject will more and more obtrude themselves on our notice, and we feel ourselves constrained to insist that too much importance can scarcely be claimed for it, as it clearly appears that it must affect alike the work of diagnosis, prognosis, and treatment of disease, which is the *raison d'être* of one of the greatest professions, as well as the progress of scientific research, as it affects the destiny and well-being of man.

Disturbed physical equilibrium necessitates, for its development and decline, "a full swing of the pendulum," so to speak, in whatever sphere of the organism it may be met, and he who recognises the part or portion of the arc of the circle involved in the particular swing, will be best able to predict when that swing will terminate, with what diminishing proportions the succeeding swing, or swings, will be characterised, the time at which equilibrium will be re-attained, and the measures, if any, to be adopted to hasten, or secure, its re-attainment ; all which is, necessarily of course, merely figurative, but we think capable of translation into actuality with the exercise of that alert intelligence, which is so abundantly displayed throughout the world of medicine and surgery.

Equilibration in matters of disease, as here foreshadowed, should, therefore, to our way of thinking, become a goal for the practical worker in these spheres to reach, and should repay the exercise of much clinical thought and effort, and keep within more scientific lines the endeavours to meet the requirements of the practisers of the healing art, as servants of the public, and for the satisfaction of their own *amour propre*.

EXTRACT XXXVIII. B.

ON THE COMPLETED SYMPATHETICO-SYSTEMIC NERVOUS SYSTEM.

THE completed nervous system may be said to embrace its own particular textures as well as, relationally, the whole of the textures to which its terminal fibres are distributed, *i.e.* the cutaneous and other surfaces in which the sensory nerve terminals terminate, and the musculature in which the motor nerve terminals terminate, inasmuch as these several structures are essential to the production of nervine response to the action of nerve stimuli, and are largely dependent for their growth and sustenance on the direct nutritive influence and pabulum, or plasma, supplied by the central nervous system. In this respect they, the sensory and motor systemic nervatures, are equally and alike outgrowths and continuations of central nerve structures, and are alike necessary for the performance of nerve function. In other words, these are the receptive and delivering instrumentalities through which, and by which, the central nervous system is dominated and directed by the indwelling mind or the non-material entity, inherent, or temporarily resident, in the material organism, and through which it acts and is reacted upon by the external world. Moreover, they represent what may be designated as the central and essential part of our being—for the life and service of which all the rest of our material economy is instrumental and subservient, howsoever elaborately constructed and seemingly essentially important its various parts seem to be. These latter represent the building, or material institution, so to speak, into which all

messages for the central government are conveyed, and from which all instructions and commands are passed out from that central government, the machinery of this government being carried about by its movable structural surroundings, is ever available for the determination of its direction and destination, save in the intervals of sleep, when the interim direction and safe "keeping of the house," are delegated to the never-ceasing services and the ubiquitous watchfulness of the sympathetic "partner in the business." The necessity for a common developmental evolution and an unbroken histological continuity of nervature and musculature thus become obvious, the central nervous system developing its future receptive and operative appendices by a continuous process of growth, or addition, until it becomes conterminous with the living and acting structures of the entire body, thus innervating its entirety from periphery to centre, and from centre to periphery, within the greater structural area of the great sympathetic nervature.

EXTRACT XXXVIII. c.

ON STRUCTURE AND FUNCTION AS OBSERVED IN THE HUMAN BODY—*PAR EXCELLENCE*.

IT may, we think, be accepted as axiomatic that every structure and organ in the human body is constructed on a definite plan, and for a definite purpose, which is repeated with but slight variation, due mainly to environment, generation after generation, in the formative processes of growth and evolution, and that, therefore, every such structure and organ has a real and, so far, a vital, function to perform within that body of which it forms a part, of a co-operating, collective whole, and in which we have to recognise it, in every instance, as an employee, or worker, in the co-operative workshop, so to speak, and not, as sometimes claimed, an inert or desiccated specimen in a museum of "survivals." The prolonged process of embryonic, foetal, and post-natal growth forms but an organic evolutionary struggle, in which the final result is the "survival of the fittest," in structure and function, in virtue of complete or absolute adaptation to special ends and requirements, and of freedom from the preceding structural limitations, due to the meeting of only temporary and passing formative wants and conditions. We may, therefore, accept it as a *proved*, and almost *self-evident truth*, that the completely developed example of the *genus homo* possesses not an atom of superfluous or functionless texture, and that every "part and parcel" of his organism has a duty to perform in his body corporate, and a *raison d'être* for its continued existence in the commonwealth of his textures and organs. In short, man may be held to

illustrate in his material organism, in its various phases of transition, the history of the evolution of life forms, vegetable and animal, and to afford the *last example* of the "survival of the fittest," not only in his individual and representative capacity as a living organism, but as an embodiment as well of the production and "survival of the fittest" in his various textures and organs, the result also of the rigorous operation of the laws of "natural selection," and the "survival of the fittest." The appraisement, therefore, of the systemic and individual values of these various textures and organs must be made with a full sense of the importance of each texture and organ to the maintenance of the true physiological balance in the everyday activities of life during its various stages.

The stages of development, and all life is developmental, comprehended within the life of the representative human being, may be summarised as the embryonic, foetal, lactative, adolescent, adult, and senile, the first five stages, or combined first stage, being evolutionary, or incremental, the last, or senile, being involutionary, or decremental : all which stages, however, constitute but one unbroken sequence of developmental events, merging into each other, and blending, so as to form a complete union. Underlying and effecting this union is the foundation, vegetative, structural, or organic arrangement of matter, by parental or transmitted agency, in virtue of which the independent existence of the incipient organism becomes effected, by what may be called the operative, or formative, potency of the primary or sympathetic nerve energy inherent in the "primordial germ," on the surrounding plasmic elements put within its reach, and capable of immediate use, so as to secure the continuity of living forms, and the succession of vital evolutionary developments "generation after generation." Overlying, or inter-penetrating, the vegetative, or purely organic and structural arrangement of this organism, is the systemic nervous system, which has been evolved from and added to it, and which ultimately, to a great extent dominates it by its possession and exercise of reason and will and the thousand and one attributes, mental and moral, evolved from psychological development, and added to the equipment of man, to enable him in

the fullest sense to "direct his course," so as to avoid the harmful and dangerous, and to obtain the safe and secure.

EXTRACT XXXIX. A.

ON NERVE FORCE, OR ENERGY.

NERVE energy is a form of force *sui generis*, yet difficult to differentiate and distinguish from some other modes of force, except that it can be produced in, and by, one form of structure only, and, so far as we at present know, can act or operate functionally through that structure only.

In its essential nature it is different from, yet resembles, electricity, and can, in some minor degrees, be replaced by it, but in all essential respects it is, as we have said, a mode of force *sui generis*. The principle of vitality, or life, is inseparably bound up with it, although vitality, or life, is observable over a large proportion of the animated world, where nerve force, as nerve force, may, or can, be inferred, but does not definitely exist.

It may, however, be inferred from these remarks, and the facts on which they are based, that the *force* animating and sustaining the lower forms of life—or those in which no nervous system has as yet been developed—or the *principle of vitality*, is no other than the *force* which in the upper regions of the organic world becomes concentrated and focussed, so to speak, and requires for its production, storage, and usage, a series of structures known as the nervous system; therefore, the *nerve force* can only be *vital force*.

In this connection, we have thought it likely that sensory impressions conveyed from the periphery, if *unexhausted* on arrival at the receiving nerve cells, may be *conserved* there, as in a "Leyden jar," for future use, as motor impulse, or "food for thought," or exhausted and used up in

transmission to higher centres, where it may be likewise further stored, used up, or, it may be, spent pathologically as a disease-exciting reflex, or reverse, current, or molecular disturbance, as in some neuralgias, *herpes zoster*, or epileptic "nerve storms."

For example, the sensory impressions, conveyed by the peripheral nerves to the ganglionic cells of the spinal cord, in a paraplegic, are, or seem to be, reflected in the form of motor impulse to the muscles of the affected limbs, which points to the conversion by the sensory ganglionic and connected motor cells, of the cord, of sensory molecular change, impulse, or impression, into motor molecular change or impulse.

It, therefore, seems possible that peripheral impressions may be thus *stored* in the cells of the spinal cord, and the higher basal and cerebral centres, and that they may subsequently, when necessary, be converted into motor impulses, or be made available for higher functional, or even intellectual, purposes, as memories, etc.

Nerve energy *may thus* be largely derived from without, and stored up for future use by the cells so plentifully present in the great cerebro-spinal system, as well as in the attached sympathetic system; and so the genesis proper of nerve force, by the appropriate nerve structures, may be supplemented and assisted by the collection and retention of unused or residual sensory nerve force.

Another thought that has occurred to us in connection with this aspect of the subject of nerve force is that a *recurrent* molecular change, or nerve current, may be induced in the motor nerve fibres, engaged in initiating and maintaining muscular action, and transmitted in a *reverse* manner to the higher centres as a *measure*, or *neurometer*, so to speak, of the amount of nerve force expended in the stimulation, or innervation, of the muscles engaged in any given act, or series of acts, or movements, and that thus an automatic mechanism is provided for the accomplishment of the objects of a "muscular sense," and that, therefore, the principle of the "*duplex current*" is utilised in the conveyance of nervine force.

Here we might further observe that sensory nerves seem to afford, in certain conditions of the bodily health,

easier *channels of exit* for the *escape* of what may be called *recurrent* or *reflex* nerve force, than motor nerves do, and that the very frequent occurrence of herpetic eruptions, in connection with febrile complaints, is an evidence of this. This latter statement, moreover, might be supplemented by the observation that spasm, local or general, is likewise very frequently a consequence of reflex motor nerve excitation in connection with numerous ailments. Be this as it may, we further draw attention to the similarity, or *parallelism*, which may be said to exist between an attack of *herpes zoster* and an epileptic seizure, inasmuch as they may both be said to be "nerve storms," the latter involving muscular contraction, and the former evolving pain and the effusion of serous fluid, besides the breaking down of the surrounding sanguineous elements by *neurolysis*. It will thus be seen that the principle of the *duplex current* is at work in both the motor and sensory systems of nerves, and that many diseases might be cited to illustrate the extent of its operation.

Along with the phenomenon of the *duplex current* in pathological conditions involving the affection of the sensory system of nerves, as distinguished from the motor, is frequently the production of acute pain, which here must be regarded as due to the *discharge*, from the sensory nerve terminals, of *nerve force*—a strange or morbid function—in contradistinction to the *receipt of impressions*—their normal function.

The genesis of the pain here alluded to, and the sense of feeling of the pain itself, are most probably to be found in violent molecular agitation of the intra-neural substance of the nerve terminals, and probably neural rupture, with subsequent escape of both neural material contents and force. Such diseases as those mentioned, epilepsy, convulsions, spasms, local and general, with pain, tingling, itching, herpes in all its varieties, as well as many other diseases and individual symptoms, may all be described as *leakages of nerve force*, due to nerve explosions of greater or less severity, or violence, and of shorter, or longer, duration, and emanating from either the motor, or sensory, divisions of the nervous system.

EXTRACT XXXIX. B.

ON A PHYSIOLOGICAL PHENOMENON CONNECTED WITH THE INITIATION AND TRANSMISSION OF NERVE IMPULSE THROUGH, OR BY, THE NERVE TERMINALS.

THE thought strikes us that the presence of cerebro-spinal fluid, or a fluid of like composition, is necessary at the peripheral, or sensory, nerve endings, in order that specialised initial molecular changes may be communicated to the terminal extremities of the axis cylinders preparatory to the transmission of proper nerve impulses, and that this is accomplished by its conveyance to, and storage in, the nerve terminals, by means of the circulatory media of the nerve fibres, and their attached peripheral expansions. This doctrine will apply both to the systemic, or general, and the sympathetic system of nerves in their afferent aspects.

It may be also, and we think must be, that a similar, or corresponding, cerebro-spinal lymph mechanism is necessary to effect the passage of motor, or efferent, impulses from the motor nerve terminals to the contractile elements of the muscular fibres, both striped and unstriped.

If this be true, we can perceive that channels for the passage, or circulation, of the required fluid are ready provided in the inter-neurilemmar spaces of the nerve fibres, sensory, motor, and sympathetic, and that the nerve terminals, in a state of health, must always contain a sufficiency to meet requirements.

Normal æsthesia may be supposed to follow a physiologically normal condition of this provision, while anæsthesia and hyper-anæsthesia may be regarded as due, in like

manner, to its pathological or abnormal conditions—paralysis and other disturbances of muscular contraction likewise following the abnormal disposition of motor terminal fibre lymph within its proper, or efferent, channels.

EXTRACT XXXIX. c.

ON IS THERE SUCH A THING AS NEUROLYSIS, AND IS
IT AKIN TO ELECTROLYSIS?

WE have ventured on the use of the term *neurolysis* here, to signify what seems to us a process seemingly akin in character to that of electrolysis, and which at times results in breaking up the physical, and it may be the chemical, union of the constituent parts, or elements, of certain physiological substances within, or in real or vital union with the body—for example, as we observe in cases of herpetic and other eruptions, where the composition of the blood corpuscles, in- or out-side of the neighbouring capillary vessels, undergoes a change, from being played upon by discharges of nerve force, their physical continuity being dissolved, and their hæmoglobin set free—staining and colouring the vesicular contents into which it escapes.

This process seems due, in such circumstances, to the action of nerve, or nervine, force on the substance of the corpuscles, or the corpuscular body substance, to which it has gained direct access, by the breaking down of the histological, or material, mechanism of the nerve endings, and by the consequent escape of the nerve energy into the surrounding circulatory and other textures; this process, moreover, as has before been contended, represents a reverse, or efferent, nerve force current along the fibres of an afferent, sensory, or peripheral nerve, which, we may be warranted in inferring, is likely to be much more destructive to a terminal nerve apparatus—whose function is to receive and transmit inward, and not to

deliver and transmit outward—than would be the case were the current in the normal direction, and through the terminal efferent nerve mechanism, which is naturally adapted to the purpose.

EXTRACT XL. A.

PHYSICO-METAPHYSICAL.

On Life.

WHAT is life? is a question that has exercised the thinking mind all along the ages, and that continues to be asked with an earnestness and persistency, more even than pristine in strength and volume, but the answer has not yet been given. Neither the simple and direct thinker, the acute observer, the profound formulator, nor the scientific or brilliant exponent, have been able to vouchsafe a reply which will, or can, satisfy the questioners; and, therefore, the problem is likely increasingly to continue to excite curiosity, and stimulate yet further thought, it may be, to the remotest generations; and 'tis well it should be so, for are not the wits of every generation thus sharpened on those of its predecessors by such exercise, and are not its views of the subject in all its aspects thereby deepened and broadened? Thus it is, that the curiosity of mankind is continually inciting to enquiry, and enabling it to add to its stock of knowledge, and to the attainment and exercise of a truer appreciation and appraisalment of its present state and future progress. Therefore, though, as thus indicated, its "bump of curiosity," together with "a little knowledge," is not unattended with danger, as the history of the race abundantly testifies, it has been of the utmost value in the progress of civilisation and the advancement of science in all its branches.

On life, as it seizes on and vitalises the raw materials

of the food supplied to our bodies, as it assimilates them during the metabolic analysis and synthesis involved in the process of nutrition, and evolves the true life of the tissues, we have already to some extent dwelt; the phenomena displayed in the life of the uni-cellular, multi-cellular, and the voluntarily controlled organism, we have also endeavoured to describe. We, therefore, now would consider the voluntarily controlled, or highest, type of life, in its origin, graduated continuance, and independent existence, as a process of evolution from a multi-cell parentage, through the contact and commingling of vitalised materials prepared and shed—vitalised, not de-vitalised—by that parentage for perpetuative purposes. This evolutionary process of parental genesis, or embryonic origin, growth, adult fulness of development, and senile decay, represents, in one individual organism, the stages of developmental evolution of living forms in general. Thus, the life of the individual voluntarily controlled organism is begun in uni-cellular fashion, just as the primitive uni-cellular organism is begun, and continues; thus also the life of the multi-cellular, but non-differentiated, or sympathetically innervated, organism is paralleled by the pre-systemic nervous system bearing stage of the evolution of organic life forms in general, while the last stage of fully developed systemically innervated organisation of the individual organism corresponds to the concluding division of the animal kingdom, in the character and manner of its innervation.

Life, therefore, as observed in the individual members of the systemically innervated creation, and as traced by the aid of palæontology, throughout the long vista of once living forms interred in the geological strata of the earth's crust, as well as observation of the at present existing fauna and flora of the globe, is found to be one in type, in sequence of organic changes and events, and in the character and intrinsic nature of the organic purposes subserved by these organic changes and events.

Thus man himself, as the highest type and example of the life forms that have descended, or rather ascended, from the first created living unit, and have peopled the ever-changing surface of the earth, its aqueous depths,

and circumambient air, may be regarded as embodying in himself, and his life history, an example of every form of life, and the operation of every evolutionary principle which has been at work in the production of individual life forms, in accordance with the conditions of their co-existent environment, for has his life experience not been uni-cellular, multi-cellular, and voluntarily controlled organic? Besides, however, typifying ever variety of preceding life forms in his own organic life changes, and physical vicissitudes, he presents the culminating example of a rationally controlled, responsive, and responsible organism, attuned to higher, and absolutely unique, and generic, or specific, ends and purposes, whereby a principle has been introduced into the regulation of the direction and modification of contemporary animal and vegetable life, which has affected, and which no doubt will increasingly continue to affect, its continuance and character. In this light it seems, without stretching unduly the scientific imagination, as if man, and his domestic pets and beasts of burden, were at last, by "the survival of the fittest," likely to be left in undisputed possession of *terra firma*, with an absolutely effective suzerainty over air and water. In that state, let us hope, he will be very, if not completely, happy, as the "monarch of all he surveys," as the director of the globe's affairs, as well as, so far as he may or can be, the determiner of its destiny!

The opinion is held by some that protoplasm can be produced in the laboratory, and the inference drawn that life can be originated *de novo*, with the comforting thought that, if any catastrophe should annihilate life on the globe, a "fortuitous concourse of atoms" would again originate it, and renewed evolution would do the rest, and ultimately restore the lost flora and fauna. This no doubt is an example, in the scientific mind, of "the wish being father to the thought." So far science has undoubtedly satisfied itself that *omne vivum ex vivo*, and that, imitate nature's productions as we may, we absolutely fail in infusing into them the "principle of life," which, after the consummate experiment of the production of pseudo-protoplasm, ought spontaneously to vitalise its elements and initiate the production and reproduction of the cell in definite

order of organic sequence and continuity. For this to ensue, we must confess, it is necessary, so far as yet proved, in all the higher forms of animal life, that two dynamic, as well as two material, entities are necessary to perpetuate life, and that these are prepared, energised, and organised by two sets of organs situated respectively in two separate living organisms, but are liable to wither or to become de-vitalised, and die, unless brought into contact with each other in a specific manner. When these protoplasmic elements, already vitalised, coalesce, and with their united energies, produce a unicellular organism, capable of assuming a multi-cellular condition, and of ultimately attaining to a degree of organic development equal to that characterising the parentage from which they originated, barring the influences of environment and improper nutritive supply—a new unit will have been added to the long total of highly organised beings capable of continuing the “line of descent” with undiminished lustre, and, it may be, in increased perfection of development.

EXTRACT XL. B.

ON LIFE—(*continued*).

LIFE, as it presents itself for observation, for the collection of facts thereanent, and for the deduction of the laws relating thereto, is to be met with in the human body on its most elaborate scale, and, in that it is always present with us, it may, therefore, be constantly studied in its most minute details and in its manifold workings, general and particular. Thus, we can trace the vitalisation of the elements of the raw pabulum with which we supply our bodies, the organisation of these vitalised elements, the working and inter-working of the organic parts of the completely developed organism, and, at last, the involution and dissolution of that organism. In this prolonged process we have to observe the sequence of material change as it is brought about by the play of vital energy on the metamorphosing food elements, and to realise the modifications undergone by these elements in their re-conversion into their inorganic condition and return to their original elemental state.

The process of vitalisation may be said to begin with the reduction of the food elements into a plastic and quasi-molecular condition, wherein they can become absorbed by the gastro-intestinal mucosa and passed into the blood directly, or circulated through the vasculo-glandular mechanism of the lacteals, where they become organised into granular and lymphocyte bodies, floating in a homogeneous fluid matrix of richly nutritious fluid, which becomes the basis of the *liquor sanguinis*. Here we see the process of hæmogenesis commenced, and the

foundation laid for the corpuscular organisation of the blood materials, and the conveyance thereby of the nutritive pabulum required by the various organs and tissues of the body. Along the sanguineous channels of the great blood circulation the corpuscular vehicles, in the shape of red and white globules, take up and convey to the most distant parts and apparently inaccessible "holes and corners" of the body the fresh materials for organic exchange, accompanied by the great fluid sweep and onward flood of *liquor sanguinis*, all of which are required for the accomplishment of the "thousand and one" processes of repair and removal, and the maintenance of structural health, which begin and end with life, and which together constitute the organic phenomena of life.

Up to this point, in the process of vitalisation and distribution of food plasma, the living units may be regarded as molecular, granular, and corpuscular in their development, and free and unattached in their movements, possessing a dynamic potency and power of material distribution fitting them to minister to the wants of fixed or non-mobile cell organisms ; but here, where the integral organised structures proper of the body are reached by the blood streams, or mobile fluid elements, a new principle in the process of nutrition comes into use, in virtue of which the fixed and non-mobile elements of that body are ministered to by the mobile elements floated to them in the form of these molecular, granular, and corpuscular units. And here, moreover, what may be described as the first great step in the ultimate phenomenon of metabolism is effected by the primary fixing and incorporation of anabolic plasma, and its complete vitalisation and assimilation on, it may be called, the "heels" of *preceding* katabolism.

When the process of cell development and interstitial incorporation of vitalised plasma has been reached, and when the cell units have so multiplied that the simple and elementary machinery of intra-cellular or nucleolar vitalisation has been outgrown, and when sympathetic innervation can no longer overtake the vital necessities of the poly-cellular organism, the grouping and arrangement of its

cells is secured by the evolution or super-addition of what is called a systemic nervous system, and finally the division of the dually innervated organism into tissues, organs, and limbs is effected by the conjoint agency of the three special plans indicated of vitalisation and energisation, viz. the molecular, granular or corpuscular, the cellular, and the neuro-systemic.

Life, as thus viewed on its positive, or genetic, aspect, begins with, or in, the process of digestion, wherein the raw elements of the food are reduced to a molecular condition, or consistence, energised and passed by gastrointestinal absorption and adeno-vascular manipulation and circulation into the great sanguineous circulatory repository, from which in turn the now vitalised, or potentially dynamic, food elements are distributed to every structural unit and tissue of the organised body, where they are vitally integrated, or temporarily attached and made fully subservient to the functional activities of life, and the living requirements of the organism, or materio-dynamic being. These bio-genetic changes constitute the materio-dynamics of the evolutionary half of life, and insensibly, but persistently, terminate in the involutionary half where katabolic change sets in, and terminates by returning to the inorganic world of matter, with the utmost precision, every atom and molecule of the raw material originally supplied for specific bio-genetic purposes, the remaining vital dynamic entity in like manner and of necessity being yielded up in its imperishable entirety and exactitude.

The two aspects of vitality presented here—the evolutionary and involutionary—to the observer of the working of the materio-dynamic phenomena of life are, comparatively speaking, of proportionately equal extent and area, and between them constitute the vast field on which matter becomes alive, lives, and dies, and on which that phase of vital dynamic activity is manifested, which becomes appreciable to conscious being and realisable by limited human intelligence, which realisation is but faintly communicable from intelligence to intelligence, through channels patent, but still almost indecipherable from the “points of view” accessible to even the highest

intellects, so far as we have been able to gather from retro-spection, intro-spection, and pro-spection of the vast field comprised within the involved areas of already explored "mind and matter," and known nature.

EXTRACT XL. c.

LIFE—WHAT IS IT? AND WHEN DOES IT BEGIN?

THE above title and accompanying questions would seem to require a treatise for their answer, and, after all, and at the best, in the present ever-progressing state of science (1902), it could only be tentative, as all preceding answers to the questions have been ; nevertheless, every attempt at an answer must allow, at any rate, the attempter an opportunity of “taking stock” of his own and others’ knowledge on the subject, and, to that extent, be a justification for placing on record any feeble effort he may be able to make towards the answer.

Life, in the concrete, is applicable as a descriptive term to the distinctively organic phenomena both of the vegetable and animal worlds, and signifies the opposite of dead, or inert, terms etymologically, which apply to the condition of matter known as inorganic. Life, physiologically, implies a state of active, organic, and synthetic, as opposed to a passive, analytic, material condition, in virtue of the play of vital energy on organisable matter. Usually it begins, or rather continues, in an infinitesimal degree, in definite units of living matter, developed by, detached from, or left by, living matter ; it cannot begin independently in dead matter, and assume, or take on itself, the characteristics of new life, therefore, a *first creative effort at least* was necessary to initiate the long succession of life forms which has unfolded itself in obedience to a *Great First cause*, and *the law of evolution*. The principle of life, as thus detached from preceding life, or living matter, may be latent, or dormant, for long periods at a time, or

may spring into immediate activity, according as the conditions of growth and nutrition come into existence and are sustained. In the vegetable kingdom and parts of the animal kingdom these conditions are usually seasonal, but in the higher animal kingdom, where seasonal vital activity is modified by the exercise of instinct and intelligence, seasonal activity gives place to, more or less, perennial activity. The conditions of life, or vital activity, include the supply and influence of caloric as a motive power in *starting the latent or dormant principle of life* of the spore, cell unit, or fragment of the preceding living organism or body, into a *repetition of the parental life-work*, along with the supply of organisable pabulum, and "the free air of heaven," with its abundant available oxygen, so absolutely necessary to all chemical and chemico-physiological processes, be they organic or inorganic.

Underlying all these conditions, and instrumental in carrying out the behests of the dormant incipient life within the living unit, and, in fact, inseparable from it, is the *other condition*, the transmission of a *latent, or potential, arrangement* of the constituent molecules and atoms of that unit, which, or whereby, on the arrival of the required vital conditions and the irresistible impulse of active, in succession to passive, life, *initiates or begins the living career of a new being*.

This last but essential condition of *transmitted latent vital arrangement of molecule and atom*, composing the primordial germ, must operate through and by some *organic mode of force*, so to speak, and some *instrumentality*, in virtue of the possession of which it can lick into organic form—on the lines of the form from which, as an organic unit or fragment, it has been detached—the organisable material within its reach. This *mode of force* we regard as really equivalent to *sympathetic nerve force or energy*, a force which is stored up and detached with, as latent or potential, every primordial or *spermo-germ cell* and *cario-kinetic cell division*, to be called into activity or formative action, whenever the arrival of the required conditions for its operation have been reached. This seemingly indefinite, but absolutely essential, vital, molecular, and

atomic fecundated condition and arrangement of the constituent parts of the germ cell, or ultimate organic unit, is the material foundation on which the *mechanism of life* rests, through which it works, and by which it carries out its incessant synthetic and analytic, chemico-physiological processes of growth and decay, assimilation and dissipation, integration and disintegration.

We shall call this "mode of force" *sympathetic nerve energy*, for want of a simple expressive generic term, and hope that it will be possible to invent a word which will give full verbal expression to the meaning, without detriment to the scientific accuracy of the phrase.

The definition, as here given, implies that this "mode of force," after its operation through *latent, vital molecular, and atomic methods*, gradually "takes unto itself" a mode of action through the definite fibro-cellular arrangement of the growing or embryonic protoplasm, which fits it the more readily and completely to reach, control, and direct all the vital processes of nutrition, growth, and life, as they become evolved in the life-history of every living higher animal organism. It thus becomes apparent, and indeed natural, that this force should reside in, be induced by, and distributed through, the structure known as the *sympathetic nervous system*, implying that it is the great and vital function of that system, to be *the instrument* in the production and disposal of vital energy or life. All organic, or merely vegetative and passive, vital processes are therefore due to and carried out by the sympathetic system, without which no life is possible, and with the lapse of which death ensues and total disintegration.

The sympathetic nervous system as developed in man, and the systemic nervous system bearing animals, is thus *instrumental* in the performance of *all organic processes*, including the processes of the genesis, growth, and maintenance of the systemic nervous system, so far as its organic origin and connection are concerned, consequently, the great physiological operations of alimentation, sanguification, circulation, respiration, nutrition, and elimination come under its control, and are carried out—all things being favourable—with absolute and automatic (we had almost said mathematical) precision and completeness. Amid all

this machinery of life in the vegetable and lower animal worlds, and in all its vital operations, we do not once see the necessity for the existence of any other nervous system, nor does that necessity arise until the conditions of life and environment so change that, more or less, "struggle for existence" on the part of the individual animal or community of animals, takes place, when—the necessity for locomotion ensuing—a supplementary and additional nervous system makes itself felt, and compels the formation, or evolution, of what is called a *systemic nervous system*, and the "introduction into the physiological management of affairs" of the *principle of a dual control*.

The material mechanism, or fibro-cellular texture, composing the sympathetic nervous system is, as we have elsewhere contended, made up of every living cell and connecting fibre engaged in the vital, or organic, work of the bodily textures, as distinguished from merely mechanical work, which is often effected through the instrumentality of textures which have ceased to perform actual vital work, but which are still continuous with the textures so engaged, and used by them as supports, points of attachment, protection media, and auxiliary agencies generally. The sympathetic nerve textures, therefore, thus comprehend every cell, with the fibrous processes uniting that cell to its neighbouring cell, and the *connexus* of such cells and fibrous processes throughout the organically active whole, and thus *necessarily* constitute all living textures, with one exception, viz. the systemic nerve textures proper, composing the systemic nervous system, which are made up of neurons or nerve units, each of which is composed of cell protoplasm, nucleus, and nucleolus enclosed in a cell wall, continuous from the dendritic processes of the cell to the outer neurilemmar environment of the nerve terminals—this cell wall and its axonal continuation, moreover, being a sympathetic nervous system product.

These statements involve and seem to justify the further statement, that there are but two vital formative and life-sustaining organisms within the individual animal body on which the whole phenomena composing its living,

working, and self-determining attributes depend, in which they are inherent, and by which they build up the organic from the inorganic material with which they are surrounded, vitalise it, and make it subservient to the functional necessities of the organised and living body. These two organisms, the sympathetic and the systemic nervous systems, have distinct functional rôles to perform, but are histologically connected, and so co-operate in carrying on their dual offices, as to accomplish the one combined vital work. As we have contended that the systemic nervous system not only innervates but nourishes the textures with which it is connected, and in which it terminates, so we would suggest and contend that, in like manner, the sympathetic nervous system throughout its entire extent innervates and nourishes every texture of the body with which it is connected, and in which it terminates, by extracting from the hæmal streams with which its cells, and what we are entitled from analogy to call processes, are surrounded, the necessary pabulum required for the nutrition of these various textures, and conveying it by what is equivalent to a set of axonal processes from cell to cell into their substance proper, for assimilation and integration. This method of nutrition of the so-called non-nervous or sympathetically innervated structures of the body presupposes the existence of circulatory facilities, for the passage of the nutritive materials held in suspension by the hæmal fluid to the cells in which it is nutritionally deposited (and where it is kept shut off from the effete systemic lymph), in the substance proper of these cell textures. And we have every reason to believe, basing that belief on all analogies of which we are aware bearing on the subject, that the principle of circulation, on the molecular scale, is used to effect the necessary conveyance and metabolic transference of the nutritive elements, by the selective and distributive agency of the cells and their attached "pseudo-dendritic and axonal" processes.

The principle of vital energy or life, and the pabulum of the various textures, are thus circulated and supplied to the various non-nervous textures, by the sympathetic nervous system, on exactly similar lines to those on

which they are circulated and supplied by the systemic nervous system to its related cutaneous and muscular textures.

Therefore, we conclude that the whole process of nutrition, apart from its purely chemico-physiological or metabolic aspects—which may be said to be moleculo-dynamic, and *really not exceptional*—is effected through nerve agency, acting along the lines of a minutely vascular nervine organisation, by capillary and osmotic circulation and molecular disposition and interchange of the elements of the nutritive pabulum, through the universal cell economy and related fibrous processes, in virtue of which the permanent structures are laid down, or built up, and maintained, and the residual and detached materials removed.

All these statements do not yet enable us to answer the question, “What is life?” but they enable us to answer the question, “When does life begin?” Thus, definite or specific organic *life begins* in the individual organism on the fertilisation of the ovum, and on the mitotic division or the kariokinetic detachment of a cell fragment; but *life began* when the first molecules of inorganic matter were imbued with vital energy, or when the long sleep of the inorganic world of matter was broken by the effulgent dawn of the coming organic day, and when first the “living form” struggled into primitive existence to perpetuate the line of living forms by a process of continuous evolution and advancement, in the manner and style of organic design and structure, until completed by the appearance of the last, and highest form, man himself.

Life, beginning thus with the first vitalisation of inorganic or non-living matter, has continued, according to scientific teaching and observation, in one unbroken but diversified sequence of organic forms, to overspread the earth's crust, clothing and reclaiming it and fitting it for the abode of man; each living unit being preceded by and detached from its parent unit or units, and reproducing its parental characteristics, while being moulded by its environment, to fit it for its advancing, or higher destiny, in the great work of “evolution” by “survival of the fittest.” The first living form, *in a sense*, therefore, still lives in its countless descendants, vegetable and animal, and will

continue to do so until the catastrophic annihilation of the globe, or the cessation of the conditions of life, render its longer continuance impossible.

The matter of which living tissue is made up may be said to begin to live, or to take on the characteristics of living, and organic matter, from its first departure from the dead and inert condition of the gross alimentary materials composing the nutritive pabulum, and to be absolutely alive, when organically integrated or organised, by any of the structures constituting a living organism or body. In a degree, *and in a sense*, therefore, the chyle, the blood, and the lymph are alive, the two former in preparation for vital incorporation, and the latter in the process of katabolic release and disorganisation—*absolutely complete life* or vitality alone belonging to the at present existent functionally active tissues, organs, and individual organisms or bodies.

Life, thus viewed in relation to the individual living human body, is, strictly speaking, a relative term, inasmuch as life *begins* in the prospective tissue pabulum, *culminates* in metabolic incorporation with the living tissue elements, and *declines* with the katabolic liberation, circulation, and outcasting of these elements.

Life, therefore, is a tripartite, but indissolubly united, transcendental entity, beginning with the vitalisation of the elements of nutrition, culminating in their organic incorporation, and ending with their devitalisation and elimination. What it *in essence is*, however, we confess our inability to realise, and are fain to *accept, in pure faith*, the truth of its absolute control over the phenomena called vital, and its imperishable existence, as a world's motive force and fashioner of living forms, since its creation till now and for ever, in the same way as we are intellectually compelled to accept the truths and the conclusions of revelation itself.

The life of, and in, the individual man begins in unicellular fashion, progresses along multi-cellular lines, culminates in sustained structural and organic activity, and declines somatically and molecularly, when, by its dynamic indestructibility, it emerges from its erstwhile material medium of existence unaffected—so far as science can offer

an opinion—and capable of maintaining a dynamic existence in perpetuity.

The matter of which the body of man is composed is thus first innervated, or vitalised by, the *commingled parental energies*, which *blend* in the innervation of the primordial cell, and the poly-cellular sympathetic nervine area, *absolutely coalesce* in the systemically innervated organism, and finally *vacate* its crumbling textures, to pursue a separate existence and destiny, freed from material entanglement.

The materio-dynamic basis of his being is thus inherited, it may be, from the first created organic unit by, or in virtue of, a long sustained and regularly improved estate, and the continued devolution, from generation to generation, of transmitted organic increment, he only taking from his environment the material and energy to maintain the bond of union during his "lifetime."

The material he inherits in the primordial cell is, or has been, already vitalised, but the material on and by which he lives he vitalises himself, in virtue of being endowed and provided for by that inheritance—that material being gradually vivified by subjection to the processes of nutritional preparation, metabolic utilisation, and incorporation, by his component textures. Man, therefore, is composed of both dead and living material, inasmuch as until the elements of his food have been converted into living protoplasm, and vitally incorporated with his tissues, they cannot be said to be actually alive, nor can the devitalised materials resulting from tissue waste be said actually to live, hence the union of his life or vital force, with his component material parts, can only be in that narrow intervening area, marking the lines of demarcation between his not yet alive, and his already dying and dead, structural elements.

The first step in the conversion of dead into living matter, and the re-conversion of living matter into dead, is necessarily a process of loosening, or liquefaction, so complete as to allow of circulation within trophic and atrophic channels respectively, leading up to, and away from, the actually living structures, in which the materio-dynamic conditions are actually those of life, and in which death gives place to life, and life gives place to death, or the

great debatable area of trophic integration and disintegration.

The aqueous element, therefore, in the economy of alimentation and life is the *sine qua non* of plasmic change and trophic utilisation, as well as physiological hygiene—being at once the vehicle of conveyance and the instrument, or medium, of exchange in the process of nutrition, thus marking the complete circulatory patency of the whole vital area, and its associated non-vital “hinterland,” so to speak.

In lending itself to the accomplishment of these purposes it becomes the basis of every organic fluid in the body, these fluids being universally derived from and returning to the *liquor sanguinis*, to be still further utilised or finally eliminated.

EXTRACT XL. D.

ON LIFE. WHAT IS IT?

ON still further studying this most cryptic subject we have become impressed with the idea that life, whatever it is in essence or reality, operates on matter by the mode of force or energy known as *nervine*, and that the dynamics of vitality consist of, so far as we can prove, or scientifically imagine, the conversion of *nervine* into proper vital energy and the physiological play of that energy on organisable matter, with the transcendental result of the *materio-dynamic* evolution of a living unit, uni-cellular or multi-cellular, with all that belongs to it characteristic of a specific and generic living being.

Vital energy, or life, having organised a definite organism, energises it by the dynamic influence of *nervine* energy, along definite lines of *materio-dynamic* circulation dependent on specific organic arrangements, histological and anatomical.

Life is, therefore, inseparable from this *materio-dynamic* connexus, and is synonymous with its functional operations, or activities, which, when it ceases to actuate or administer them, lapse temporarily, or permanently; temporarily, when the systemic nervous system is in functional abeyance, and permanently, when the sympathetic nervous system ceases to functionate.

It is, thus, made up of nerve energy in union with organised matter, which it inspires, so to speak, and vitally administers, in conjunction with that inscrutable, but absolutely existent and persistent entity, the individual ego, or self-conscious and reasoning being, or essence—an

entity equivalent to the "spirit" of theology, and altogether undemonstrable by the most finished and scientific methods of research, although clear to "the mind's eye," and acceptable as an article of scientific faith. Nerve energy, in actuating the machinery of life, allies itself with, or actually becomes, muscular energy, operates through capillary attraction and subtle forms of chemico-physiological affinity, and accomplishes the dynamics of life by affiliating itself with the physics and chemistry of "organism in action."

EXTRACT XLI. A.

ON HUNGER AND THIRST.

THESE are two expressions that must have been in use since the origin of articulate speech, and which have a more or less definite meaning throughout the whole domain of animated nature, as well as inanimate, for over large tracts of the globe is it not periodically realised that the words "the showers that usher in the spring and cheer the thirsty ground" are true to nature, and that "earth hunger and thirst" is not a mere "form of words," but a truthful description of a natural condition? The feelings or sensations expressed by them are but too well known to many of the sons and daughters of Adam, and cannot be long absent from the experience of any and every member of the human race. Moreover, they are the great *determining agencies* in providing for the continuance of life in every living creature, spurring it on to procure the "means of existence" by the assuaging of their imperative insistence and satisfying their demands.

Do the views expressed in the foregoing pages enable us to realise their meaning to any further extent than "the man in the street" is fully conscious of? We think they do, and we shall, therefore, attempt to extract some justification for making the sanguine assertion.

Let us begin with the feeling or sensation of thirst—first, because of its greater prevalence and more oft-recurring character, and let us localise the feeling or sensation, so as to derive as much physiological light as these views, when focussed on the subject, can shed on it, in order to perceive, in true perspective, its relationship

to our organic needs, which it is intended to satisfy. The feeling or sensation of thirst in the human subject, when localised, is, in its first or earlier stages, experienced, broadly speaking, in the fauces, and in its second, or later stages, in the whole glosso-pharyngeal area—the feeling or sensation itself beginning with slight drying of the natural moisture of the affected mucous surfaces, this drying, as the thirst increases, assuming the proportions of complete inspissation of all intra-oral and pharyngeal moisture, and the closure of every gland exit in the combined cavity of the mouth and pharynx. Why is this feeling or sensation of thirst confined to this anatomical area? And can there be anatomical reasons for it? To the latter question we simply answer “yes.” To the former we shall essay to give our answer in some detail. The region, or regions, affected by thirst, as thus described, coincide exactly with the areas through which escape the secretions of the pituitary body and the salivary glands, and, therefore, compose, or cover, the scene of the first stage of the prolonged process of pan-intestinal digestion. The necessity for the continuous presence of moisture here, or, in its absence, thirst, therefore, becomes intelligible when we realise that the escape of pituitary matter is only possible in the presence of a liquefying agent, such as saliva, and that the patency of the pituitary canals, and the lacunal inter-spaces of the tonsillo-glossal area through which it escapes, can only be maintained by the existence of open exits, providing for the free discharge of intra-cephalic debris after it has passed through the pituitary body—this necessity becoming of no less than vital importance when the effete products of brain waste, as they enter the third ventricle, cannot find an escape by the central organs of cephalic drainage and cerebral hygiene, and when, accumulating, they inundate the related cerebral intra-spaces, and communicating cerebral extra-spaces, to the physical detriment and functional disturbance of the whole systemic nervature.

The feeling or sensation of thirst may thus be said to arise from the curtailment of the freedom of excretory circulation from the central areas of the brain, and

necessarily that of all the related circulations, primary and secondary, neural and hæmal, preceding that final circulatory act of cerebral residuum disposal. Thirst, therefore, primarily concerns the systemic nervous system, and is a "cry," or warning, from that system particularly, as it were, that the indispensable element of moisture must at once be supplied by the responsible agencies if the continuance of systemic nervine activity, and all that that implies, is to continue without jar or friction, and the unimpeded "work of life," organic and personal, to go forward with comfort and pleasure.

While, as we have said, the systemic nervature thus gives the initial conscious warning—deducible from the first, it may be, somewhat vague sympathetico-systemic local suggestions of the necessity of increased moisture in the body generally—to the sensorium, we must not ignore the more general, and it may be still more vague, suggestions due to general or local promptings of the sympathetic nervature, pure and simple, in its supervision of the organic work of nutrition, and all the related circulatory phenomena and processes communicated along its "*rami communicantes*" to the systemic nervature, and thence to the central and directing consciousness and responsible and responsive intelligence.

This feeling or sensation called thirst is, therefore, localised in the glosso-pharyngeal mucosa by the existence of anatomical and histological continuity or sequence of textural elements, uniting the central nervous system to the buccal cavity, and the co-existence of physiological conditions, which focus themselves in the mucosa of that region, and which give an almost articulate expression or language to the set of conditions regulating the supply of the liquid element to the formative or organic machinery of the body, which, if interpreted aright, results in the production of the happiest consequences, but which, if misinterpreted or wilfully misread, may result in the most disastrous manner, and with the direst consequences.

The local association of the feeling of thirst, and the sense of taste, implied in their respective anatomical distributions, indicates that the localisation of the former has

eventuated by natural selection, and been determined with the intention that its gratification might always be safeguarded by at least the local presence and supervision of one special sense, and that that sense, moreover, should be specially adapted to meet the special wants necessitated by such a situation.

The feeling of thirst is, thus, an index of liquid requirements, exercised physiologically on behalf of local and general systemic and sympathetic needs, and a regulator of the quantity and quality of the liquid, as well as the manner and method of its supply; hence the necessity for understanding aright, and following at all times its true meanings and purposes.

Hunger, in like manner, primarily manifests itself locally, and secondarily more generally and indefinitely; locally it is experienced in the gastric region as a feeling of regional vacuity or more or less vague faintness, or "a gnawing void," and a more or less pronounced craving for food, while generally there may synchronise with this a feeling of declining tone and strength. Is this feeling, like the feeling of thirst, localised by anatomical and functional conditions? We think so. Why? Because it occurs at the seat of the first great digestive procedure, and is usually realised when the contents of the stomach have been removed by absorption, or passed into the small intestine, at which time the gastric juice is allowed to impress the gastric wall, and the nervature distributed therein, and so to indicate that, for the time being, gastric digestion has been completed, and that there is a coming necessity for the renewal of digestive material for the satisfaction of the feeling. This feeling may be regarded as of the greatest functional value in the economy of nutrition and organic or formative activity, inasmuch as it affords an index of the nature and quantity of the required ingesta, and then ceases to send its messages of demand as soon as its requirements are met and security for the continuity of the nutritive process maintained.

Thus, like thirst, hunger may be regarded as a cry, or warning, to the economy that solid matter or food is required for organic purposes if the processes of life are to continue. It may, therefore, be understood as largely

emanating from sympathetic sources, and an expression of material voids or vacancies in the molecular condition of its organic elements and textures.

Hunger and thirst may thus be regarded as sentinels at the portals of the sympathetic and systemic nervous systems respectively, giving warning of the necessity of the neuronal communities and dependencies within to the guiding instincts and reason of the central nervature, and superintending the supply and distribution of organic pabulum to its required destinations.

EXTRACT XLI. B.

ON "FOOD AND DRINK."

Food and drink, in a sense, may be described as the *raison d'être of organic existence*, alike in the vegetable and the animal worlds, between which, in these matters, a process of give and take exists on every hand, the balance of advantage resting with the one or the other according to the *laws of battle*, which are not always in favour of the "swift" or the "strong," but which, on all occasions, may be said to eventuate, in the long run, in the survival of the fittest by "natural selection," in agreement with the dictates of "evolution," character of "environment," and hereditary advantages. The want of food and drink is *felt*, and sensibly, or insensibly, realised by every organic unit, and must be *satisfied* before that unit can have any satisfaction in life—life, in this sense, consisting of a struggle for food and drink in order that it may survive and perpetuate itself. In the obtaining of food and drink, the life-work of man is mainly spent, and the manifold industries and commercial enterprises of the world are endlessly maintained by his daily recurring absolute needs and his acquired tastes—the character of the needs may, hence, vary with the passage of time and the prevailing tastes, but their satisfaction is rigorously enforced with unerring feeling or instinct, which, if properly appeased, is followed by the best results ; but which, if met with wrong devices, must be followed with corresponding results.

Food and drink, or the solids and liquids of everyday sustenance, enter the body by a common orifice, become intimately mixed and blended, so as to afford a common

element for the gastro-intestinal absorbents to work upon, this common digestive element being known as chyme and chyle, according to the stage of digestion reached, and the amount of chemico-physical change undergone. After its absorption, we may take it that the process of organic assortment is in full operation, every step of it being marked by a chemico-physiological elemental change and organic evolution, resulting in sanguification, structural deposition, and complete organisation, after which, by inverse, or disorganic processes, the removal of the worn and waste products of organisation is effected in perfect order, and with vital regularity.

A form of consistency, solid or liquid, is consistently and consecutively maintained throughout the whole intracorporeal circulation of each of the food elements, one or other of which may be experienced by each of them, as they become utilised for organic purposes, or ultimately detached for excretion. Solid and liquid represent the consistency of the various new elements constituting the ingesta, the various organic textures, or substances, representing the formed organic constituents of the living organism, or the body; and the various residual substances, sold and liquid, eliminated from the ingesta and the egesta, exactly balancing each other in physical weight, but altered chemical proportion. It, therefore, follows that, any departure from this condition of physical exactitude, must be obviated, else a condition of pathological disturbance must result in proportion to the amount of departure from the physiological standard.

In order that that standard, the physiological, should be maintained, the quantity and quality of the ingesta must be rigorously meted out by the presiding physiological regulators, which here are called appetites, and are known by the names of hunger and thirst, the first of which is responsible for the regulation of the solid ingesta, and the latter for that of the liquid; both, however, being subject, in the human species, to the oversight of reason and accumulated experience, acquired and inherited.

EXTRACT XLII.

ON THE PHYSIOLOGICAL NATURE AND IMPORT OF THE ACTIONS OF YAWNING, STRETCHING, AND SNEEZING, ETC.

YAWNING, explained by the lexicographer, "is the act of opening the mouth from drowsiness," and so it has been shortly described since the English language was evolved from its original elements. No doubt, if we could penetrate the mists that surround the early history of our race, we could get glimpses of the fact that it has always held a place in the list of human *enjoyments* and *sorrows*, and we can plainly see it amongst our domestic friends, both canine and feline, and in the various grades of our nearer relatives, the quadrumana.

We thus observe that it is one of the most widespread, and, at the same time it may be said, one of the least heeded of our everyday, oft-repeated, involuntary, or automatic acts.

The act, when patiently analysed, is found to be a very elaborate and complex one.

The complete and *unmitigated yawn* may be described as follows: First the disposition to yawn becomes overpowering, then the chest is completely filled by a deep inspiration, the mouth is opened to its full extent, and (when not combined with the general act of "stretching") the muscles effecting these movements are relaxed quickly, or more slowly, which event is at once followed by the more or less vigorous contraction of the opposing sets of muscles, with the result that the various local *gland* structures, but mainly the lachrymal, tonsillar, and salivary,

and their vascular and circulatory textures, are mechanically compressed, and partially emptied, the "tears then springing into the eyes," and down into the nostrils, and the saliva "welling" into the mouth.

This act then becomes *in our estimation*, when viewed in the light of its probable functional value, one of the very greatest importance in its relation to our physical, and, it may be to some extent, to our mental comfort and well-being. And here, perhaps, it may be well to express our surmise that there is a difference in nature and intensity between the night and the morning yawns, the former preceding and ushering in *sleep*, and the latter completing the act of *awakening*, and that, in a manner, the yawn acts as a switch in the economy of inhibition.

When exhausted, wearied, bored, or suffering from *ennui*, and sorely needing rest, the handle, so to speak, of the inhibitory mechanism is seized by the needful yawn, and held, until finally it falls from its grasp, as sleep asserts its sway. After which, sleep's sway is enjoyed for a season, or until nature's requirements have been met, when the act of awaking once more instigates the yawn to "turn the inhibitor," and the more vigorously its powers are exerted the more, in proportion, is felt the "sense of refreshment" from the preceding slumbers; when again the eyes are bathed with lubricating moisture the nostrils are flushed with the superabundant lachrymal flood, and the mouth and fauces are irrigated by the expressed saliva, and tonsillo-pharyngeal mucoid excretion. Thus the machinery of at least *three* of the senses—sight, smell, and taste, and probably hearing and touch—is refitted for the *comfortable* and more efficient performance of duty. Therefore, we say, let the yawn have *complete* local and general control when the exigencies of etiquette will allow, and if these latter forbid, then the very first opportunity should be seized of gratifying *waiting nature*. We refrain, however, at present from entering on the subject of the therapeutic value of *this essential and natural act*, and the description of a *regulated system of yawning and stretching exercises*—the elaboration of which should be fraught with great physiological benefits.

The act of stretching may be called the completion of the act of yawning above described. It is equally, or even more generally, apparent throughout the upper regions of animal life, and is indulged in with an *inspiring* air of satisfaction and energy, which, in many instances, is followed by an evident improvement in morale and physique alike of its subject.

A deeper inspiration and a consequently full thorax are again, as in the yawn, the starting-points of the series of movements which constitute "the stretch." With the deep inspiration the arm, or arms, are raised to various heights and angles, turned and twisted, the neck, with the head, is pulled backwards until its anterior muscles are put well on the stretch, when an undulatory movement of the muscles of the trunk, from top to bottom, sends a wave of curvature down the spinal column, which loses itself in the lower limbs, and is projected, alternately flexing and extending them, to their farthest extremities—these movements sometimes repeating themselves again and again.

On a patient analysis of the phenomena, constituting an "act of stretching," it is seen that the first "motor impulse," after the initial deep inspiration, is communicated to the "extensor musculature," which responds by inducing an *almost simultaneous* or *immediately consecutive contraction*, by which the dorsal aspect of the body is shortened and the posterior surfaces of the limbs tightened, throwing the weight of the body, if recumbent, on to the occiput and heels. This contraction, after continuing one or more seconds, relaxes, and is succeeded by a second "motor impulse," which is communicated to the "flexor musculature," and the ventral aspect of the body and limbs, whereby the body and limbs are made to form an arc of a circle by bending forward the head and thorax and tilting upwards the feet and toes.

These impulses, and consequent muscular contractions, when well marked, are sufficient to bend the body in either or both directions, and even laterally, by a slight alteration and addition to muscular action, to an angle of from ten to fifteen degrees, and are continued in

rhythmic succession and gradually declining intensity until the condition of rest is ultimately regained.

So rhythmic and continued is the act sometimes, that a see-saw feeling is experienced throughout the body for a period of time, very much akin to what the unseasoned sailor is familiar with on regaining *terra firma* after a voyage on the "briny deep."

Who then can *doubt* the importance of this act, or series of actions, in the economy of a complex organism like a living vertebrate animal?

It slows the pulse considerably, lessens the number of the respirations, and is succeeded by a feeling of oscillatory movement, which lasts for some seconds, or until the function of respiration is *fully resumed*.

The muscular system is thus like a stringed instrument, "attuned" to the proper performance of its duties, the motor and sensory nerve trunks are straightened out, so that nerve impulses can travel to and fro without interruption, the slow and unapparent lymphatics receive a stimulus, mechanical and vital, which expedites their circulation, while the interstitial cellular tissues are, more or less, unloaded of their passive contents, and the blood circulation, although slower, strengthened and steadied. Moreover, it further seems to us, that the whole liquid contents of the nerve structures sustain a push, by which their position is, more or less, changed within their enclosing sheaths, and their regular distribution improved or more completely obtained.

"Sneezing"¹ is one of the same class of acts as

¹ On June 29th, 1899, we wrote to the Editor of the *British Medical Journal*, as follows: Dear Sir,—A medical friend of mine, who is acquainted with some work I have done during the last twenty years in certain departments of neurology, has drawn my attention to a "Literary Note" which appeared on page 1552 of your issue of the 24th inst., and which reads as follows: "A work by Dr. St. Clair Thomson entitled 'The Cerebro-Spinal Fluid, its Spontaneous Escape from the Nose,' is in the Press. The book will be published by Messrs. Cassell & Co."

Before the publication of the work above referred to becomes, or is accomplished, my friend thinks, and I agree with him, that it is necessary for me to ask you to be good enough to allow to appear in your earliest available issue the following extract from a paper entitled: "On the Physiological Nature and Import of the Actions of Yawning, Stretching,

yawning and stretching, and is not infrequently associated with them. The stimulus to the act of sneezing is usually felt within the nasal cavities, and may be produced by the presence of an irritating particle, or as a reflex stimulus from the optic organs, such as is produced by "looking at the sun," and, as it seems to us, from a distension of the Schneiderian membrane, due to a *vis a tergo*, exercised by pressure from superabundant cerebro-spinal fluid, such as occurs in the course of a "cold in the head."

However caused, the act of sneezing consists in filling the chest for a supreme effort to clear the nasal cavities of the offending influence. The act in itself is often experienced as a great relief, sometimes, however, it is attended with rather painful feelings, and may assume a pathological character. In the sneezing ushering in a cold in the head, it sometimes at once unlocks the cerebro-spinal spaces, relieving them of their pent-up contents, in the shape often of copious streams of clear, somewhat saline fluid. This occurrence being so frequently attended by appreciable lightening of the sense of weight in the frontal region, and, it may be, by disappearance of the pain experienced in such ailments as gravedo, coryza, etc., may thus be regarded as a *natural curative agent*.

In the light of the preceding remarks we would conclude that the nostrils are two of the natural outlets or channels by which the overplus of cerebro-spinal fluid is run off

Sneezing, etc.," which I read to a company of professional gentlemen in the beginning of the year 1895, and which, along with much more matter of a kindred character, is now awaiting publication in serial or book form. Sneezing is one of the same class of acts as yawning and stretching, and is not infrequently associated with them. The stimulus to the act of sneezing is usually felt within the nasal cavities, and may be produced by the presence of an irritating particle, or as a reflex stimulus from the optic organs, such as is produced by "looking at the sun," and, *as it seems to us*, from a distension of the Schneiderian membrane due to a *vis a tergo* exercised by pressure from superabundant cerebro-spinal fluid, such as occurs in the course of "a cold in the head," etc.

Dr. St. Clair Thomson's work appeared in due time, and proved to be a most exhaustive description and recapitulation of every published case of what constitutes a *pathological demonstration* of the *physiological condition*, to which the above quotation is related, and which is elsewhere in this work with much more detail described, along with its factors and the associated cerebro-spinal outlets and excretory phenomena.

when superabundant, and that the many openings, or foramina, piercing the ethmoid bone are fulfilling the great purpose of regulating the quantity of fluid within the cerebro-spinal cavity, of maintaining the equilibrium of intra-cranial and intra-spinal pressure, and of thus securing the integrity of the important structures contained therein—the process of osmosis, with capillary circulation, being utilised to effect the purpose.

Generally, or at any rate often, a feeling or sensation is experienced in the *central nasal* region for a more or less brief period, and of more or less intensity, preceding the act of sneezing. This feeling is excited by each and all the stimuli or irritant influences *capable* of causing the sneeze. But when a “cold in the head” is being caught, it seems due to the operation or influence of a *vis a tergo* pushing the contents of the olfactory apparatus through its neuro-capillary or terminal fibres.

In controlling this outlet from the cerebro-spinal cavity, and acting as so many sphincters, so to speak, it appears to us that an agency is provided in the muscular fibres distributed within the structure of the Schneiderian membrane.

The presence of these muscular fibres in the substance of this membrane is difficult to explain, unless we concede to them some such function, when, if we do so, their presence at once becomes a *part of a great plan*, and is recognised as a wonderful provision. We, therefore, contend that they are, and act as, a series of sphincters, to regulate the flow of the outpouring cerebro-spinal fluid, and also that they act as guards against the entrance of foreign particles from without. Hence the difficulty of entrance through these channels of any except the smallest of disease germs known to science, such as the influenzal, but where an exit is allowed, however small, there must of anatomical necessity be an entrance correspondingly small.

Hence, also, the possibility of the entrance of such minute organisms into the cerebro-spinal cavity by the other channels numerable in this connection, viz. the pituitary apparatus, the coccygeal mechanism, and the sweat glands generally.

The removal of offending particles from the surfaces of the nasal passages, for which an act of sneezing has

been called, is effected by a jet, or whirlpool, of air set in motion by the expulsatory action of the respiratory muscles primarily, and by the oozing of cerebro-spinal fluid through the Schneiderian mucosa, due to the opening of the glands of Bowman secondarily. Thus, they are either *blown away* or *washed away*.

The new-born infant very early, or, in many cases, immediately after breathing, gives evidence that the peripheral nerves have become disturbed or affected—through the change of temperature of the medium by which it is environed—by an effort, or succession of efforts, at sneezing. Thus, the changed circumstances of the child's existence necessitate an easily available provision for the regulation of intra-cranial and intra-spinal pressure—the equable temperature of its hitherto immediate surroundings having been such that the cutaneous surface and other convenient channels have been sufficient to afford the required means—whereas now the constantly changing temperature of the surrounding air, into which it has been born, is so “trying” for its peripheral nerve terminals that a correspondingly increased provision of protective mechanism has had to be secured to prevent disaster.

The sigh may be called an *echo* of the *stretch*, and is often attended by the *proverbial relief*.

Weeping belongs to the same category of, more or less, involuntary actions, and is only seen in human beings, although in one or two instances it may be said to be closely counterfeited, such as in the case of the proverbial “crocodile's tears,” and certain howls of the dog and its congener the hyena.

The whole of these *natural movements*, and combinations of natural movements, seem to be the outcome of “*natural demands*,” and are the *finished methods* by which nature effects needful changes in the static conditions of the fluids of the body, and secures the equilibrium both of the material and dynamic conditions of it generally, and of the various organs and structures of it particularly.

This exhaustive study, therefore, cannot fail in enabling us to possess ourselves of a great natural means of meeting natural systemic needs by natural systemic methods, in natural systemic manner.

Further, in an act of sneezing we perceive that the stimulus—whatever it be—if it be sufficiently strong to determine the act (because it may be abortive, which often happens) produces reflexly a closure or narrowing of the pharyngeal-laryngeal spaces or passages by a contraction of their encircling musculature, followed by a violent expiratory effort, with the effect that the expired air is made to project into, and sweep through or traverse, the nasal cavities, removing the cause of offence, or intensifying the initial irritation. Two sets of muscles are thus brought into action, viz. those that cause contraction of the upper part of the respiratory tract, and those that produce a violent act of expiration, the contraction of the former being overcome by that of the latter.

Along with the series of events occurring in an act of this kind in the naso-thoracic regions, we find that a wide-spreading disturbing influence is produced which makes itself *felt* to the remotest extremities of the body, but necessarily where its contents are most liquid, hence the fluid contents of the cerebro-spinal spaces and inter-spaces, amongst the others, are more or less violently set in motion towards the periphery of their combined area or extent, or particularly along the most yielding channels connected therewith, two of which, in particular, are the olfactory tracts, with their attached nerve endings.

EXTRACT XLIII.

ON THE NATURE OF BLUSHING, FLUSHING, AND BLANCHING OF THE HUMAN "CHEEK" AND SKIN.

THE terms here enumerated are as "old as the hills," and are as familiar to every white man and woman as the "air they breathe" or "the raiment they put on"; besides, have they not given employment to the pen of the poet and the brush of the painter since inspiration stirred the intellect of genius? And do they not still constitute a theme for thought, and afford scope for the use of language at once picturesque and intense? Into this department of the "overwhelmingly interesting" subject it would, however, be nothing short of sheer sacrilege to enter; we, therefore, take up, as more germane and relevant to a strictly scientific treatment of such a physiological problem, the anatomical and histological lines along which we think there is a prospect of arriving at more or less definite conclusions regarding it.

We have elsewhere endeavoured to point out that there reside in the skin of the body generally, but *par excellence* in the skin of the hands and face, a dual vasculature, engaged in circulating fluids of very different character and colours, and that these vasculatures maintain their varying patency by virtue of their connection, and continuity with, and of their receiving their contents in different manners from, their respective "fonts of supply"—their *raison d'être*, indeed, being the transmission, or circulation, of the hæmal and neural fluids.

Of course, it should be mentioned here, for the sake of histological reality, that a third vasculature exists, viz. the

lymphatic, but that it *does not enter* into the causation, or regulation, of the phenomena in question, its presence only becoming known in connection with certain pathological conditions in particular.

These vasculatures, being the capillary blood-vessels, and the nerve terminals of the skin, and, consequently, circulating blood and cerebro-spinal fluid plus neural plasma, respectively, necessarily colour the skin through which they are conveying their contents, strictly in accordance with the proportions in which, for the time being, the two fluids are circulating. Thus, for example, under the stress of severe or sustained bodily exercise, it will be found that the blood contents of the capillary vessels, continuously pumped hither, at last superabound and overshadow those of the nerve terminal vasculature ; hence the flushing, hence, also, the blushing of shame or remorse, when the heart, violently agitated, projects its contents into these tell-tale regions, and measures out, with more or less fidelity, its depth and character ; hence, also, the blush which mantles the "cheek of innocence," through the influence, it may be, only or merely of a "shade of thought," and the quick response of a cardiac organism attuned to neural impulses and cerebro-cardiac sympathies. Thus also, under the influence of shock, fear, or "intense feeling" of various kinds, we may witness the counterpart to these hæmal displays in the temporary, and, alas ! sometimes the permanent, arrest and withdrawal of the circulating blood from the blanching cheek, and the intensification of the natural pallor by stronger and fuller invasion of the neuro-terminal vasculature by the pale and colourless elements of the cerebro-spinal lymph streams and the pearly nerve plasm, with the final disappearance of every vestige of colour, as the pall of unconsciousness falls over the thousand-fold activities of the sensorium, and "life in death," or death itself completes the scene.

In trying to appreciate the phenomena of the flush, the blush, and the blanch, we must bear in mind that in doing so we are looking upon a histological collection of microscopic vessels of varying lumen, conveying differently coloured and shaded fluids, actuated by a dynamic organism, sensitive to the slightest influence flowing from its

environment from within or from without, and above all, initiated and determined by the most transcendental of human attributes, viz. human consciousness and emotion ; we must further bear in mind that the whole mechanism, material and dynamic, concerned in the formation and expression of these phenomena is but an *instrument* for the recording of characteristics which may be "known and read of all men," an *instrument*, moreover, that can be "played upon," and can "emit a music," ranging in height and depth of tone and quality within limits as wide as those of the human race.

A rhythm and play, moreover, characterise their occurrence, which sound to the very depths the seas of human happiness and sorrow, and which lend a halo of romance to even the commonest life, when viewed in its relationships to all that is noblest and best, and all that is coarsest and worst in the great human cosmos.

Pleasure may be seen depicted in the least expected quarters, and pain and suffering where they were not suspected to have obtained a footing ; yea, here can often be read the truth of the oft-repeated saying, in the calmness and imperturbability of right thinking, saying, and doing, that "virtue is its own reward."

Flushing and blushing are due to increased blood pressure throughout certain generally well-defined areas of capillary circulation, while blanching is due to retarded, or abolished capillary circulation plus, most probably, increased neuro-terminal circulation, with culminating stasis, as the condition assumes the character of permanency. At a glance it will be seen that the opposed states of flushing and blushing and of blanching cannot possibly co-exist, inasmuch as they are the outcome of diametrically opposed conditions, flowing out of the involvement of two differently constituted vasculatures, and the existence of two differently coloured circulatory fluids, and that they must, or do, fluctuate in the order of their occurrence and continuance. Moreover, a distinct value attaches to the power of being able clinically to read the nature and meaning of any departure from their normal form of occurrence, or any perversion of nature's methods of showing on the surface the method of the more deep-seated working of the

machinery within, and of the indications presented as to measures of rectification. A profound contrast must here be recognised as separating the two different sets of fundamental conditions, viz. the hæmal and the neural, and determining the character of contingencies, diagnostic and therapeutic. In dealing with many of the more ordinary dermatological problems, the clinical use of the above observations may also claim some value.

The degree of intensity to which the phenomena of blushing, flushing and blanching may at any time reach is, no doubt, regulated by vaso-motor innervation, so far as it is the outcome of hæmal circulation, but the profundity of the degree to which blanching may reach may be regarded as the outcome of accentuation of neuronie circulation within the neural vasculature and stasis, or it may be increased flow of the neural fluids within the nerve terminals of the parts involved. Circulation thus, once more, becomes the key to unlock the problems involved in the natural phenomena of blushing, flushing, and blanching of the skin of the cheek and of the general cutaneous surface, and illustrates again the truth which we have so often repeated : *circulatio circulationum, omnia circulatio*.

The phenomenon of diaphoresis is intimately associated, on many occasions, with the phenomena of blushing, flushing, and blanching, so much so indeed that a clue is afforded to the explanation of the sequence of the physiological events which make them up ; thus, the flushing of violent exercise throws on the sudorific exits more material than can be passed through them in their usual or normal condition, hence we have sudoral accumulation and hindered hæmal circulation, culminating in more or less pronounced stasis and rubicundity of surface, while blanching, as a contrast, may be attended with the most profuse diaphoresis.

EXTRACT XLIV. A.

ON METAMORPHISM.

METAMORPHISM, or the process of metamorphosis of tissue materials, is observed in the evolution and growth of all vital organisms, as well as in the involution and decadence of these organisms as displayed in post-primal age or the "decline of life."

Metamorphoses of tissue formation and, in many cases, of external form, are so numerous and apparent, and have been so exhaustively treated and elucidated by the botanist and zoologist throughout the two kingdoms of animated nature, that it seems unnecessary to do more than call the attention of those interested in the subject, in so far as it relates to their peculiar departments of science, in order that the evolutionary processes of metamorphism may be utilised to explain and illustrate the converse, or reverse, involutionary processes of metamorphism undergone by vital textures in their period of decline and devitalisation or resolution.

Evolutionary metamorphosis, as here implied, may be shortly described as a process of change from a lower to a higher form of structural arrangement and functional rôle, whereby a stage of stable and perfect formative attainment is ultimately reached by the organism in its various parts and textures where, and in which condition, it continues for a variable period according to the nature of the organism, when, or after which, a process of decline or involution sets in, and lasts till the vital cohesion of its component structural parts can no longer be maintained, and death ensues as the inevitable consequence. These

changes constitute the life history of the organism whatever it may be, and afford an index of the age, or stage, of development to which it may have reached, and, therefore, the probable length of time it may yet have to live, the clear apprehension of which, consequently, sometimes becomes a matter of great moment under certain circumstances. The sequence of the steps, or stages, of evolutionary metamorphosis, we think we are warranted in concluding, must bear a somewhat definite relationship to those of involutionary metamorphosis, and, we further think, generally in the manner of inverse order of sequence or occurrence. Thus, the muscular strength in the case of men and the higher animals, as it is the last of the physical attainments to be perfected, begins to fail first, usually while the cutaneous covering and appendages—pigmentation included—begin to show almost simultaneous signs of involutionary change, or decay, both occurrences being dependent, according to our belief, on failing nutrition, due to lessening of their nervine pabulum, which most likely is retained, or diverted, to some extent at least, for increased or intensified purely cerebral or intellectual work. Thus, the commencing and the growing enfeeblement of the muscular tissues, the falling off and whitening of the hair and the wrinkling of the skin, which herald the advent of the decline of life, all belong to, and are induced by, the failure, or diminution, of the supply of the nerve plasmas used by these structures, which are conveyed to them by, or through, the nerve terminal channels of the afferent and efferent nervatures, from the cerebral, spinal, and ganglionic nerve cells respectively—the rounded outlines, plump features, and ruddy health of youth and primal manhood merging into coming age, and disappearing with the gradual progress of decay and degeneration, leaving only an organic wreck behind.

Involutionary metamorphosis, as thus begun and exemplified in the muscular and cutaneous textures, pursues its degenerative course through the whole series of structural and visceral elements composing the organism, laying hold of one after another very much in the order of their original development, or on lines dictated by their respective powers of resistance, and their degree of

perfection of original formation and preservation of healthy characteristics—the vital powers, as exercised by the systemic and sympathetic nervatures, succumbing seriatim to the cumulative influence of chemico-physiological or pathological change and negation.

In this process of involutionary metamorphosis we may be prepared to find the beginning of many diseases due to spontaneous failure of the vital powers to resist the natural tendency to degeneration and decay, intensified, it may be, by conditions of life destructive of health operating along physiological, chemical, bacteriological and other lines, and dragging the unfortunate subject, it may be, into premature age and death.

It would not be too much to say, in connection with these views, that such a disease as cancer may be proved to have its origin in the pathological, and not in the physiological, disposal of structures, whose office and presence in the system are no longer possible, and whose removal, therefore, has become a functional necessity and a condition of health to that economy; and that the proneness to attack by that disease of organs, whose functional rôle is curtailed or ended, has herein the explanation of its probable etiology and pathology. The necessary liability to pathological change of these structures, and their lessened power of resistance to the incidence and influence of morbid agencies, render them at all times a source of danger, amid the tumult and friction and concussions of life, to their possessors, and hence, in dealing with affections of such a character, we have thus provided a point of view from which to regard them which may be fruitful both of diagnostic and practical results. Thus—*par excellence*—we observe that the female suffers from this disease, to a greater extent than the male, and just in connection with organs and structures whose functions are early closed and ended, viz. the mammary glands and the uterus and appendages, whose involutionary metamorphosis is so wholesale and complete as to outrun, in many cases, the absorptive and eliminatory powers possessed by an adynamic and enfeebled organism, and, hence, to leave a structural residuum peculiarly prone to become the seat of disease and pathological change; in this

condition of things, therefore, we have a nidus in which spontaneous retrogressive changes are continually in progress, and what more natural, therefore, than that these changes should be pathologically hastened by one or many of those parasitic or bacterial tenants, which, from time to time, or, it may be, always, are in possession of the living body for good or ill, and whose eviction, when evil, it becomes the great necessity of well-directed prophylaxis and therapeutics to obtain in the first place, and surgical measures in the second? The *materies morbi* of cancer, whatever it may be, is a morbid agent or tendency, or both, which can only become actively harmful when the individual organism has entered on "the down grade," and when its metamorphosing tissues have, consequently, lost that vitality which alone is able to confer and maintain their immunity from, or under, attack; it must thus be necessary, in order to meet such conditions, that the greatest heed should be taken in order to anticipate and forestall the attack of the *materies morbi* by the maintenance of as robust a physical condition as can be obtained, and the withdrawal of all vulnerable metamorphic matter as far as that can be accomplished. So, we think, it will be possible, to some extent, to meet that clamant cry and want of the present time by a rational and, to a certain extent, scientific adaptation of "means to ends." Those, therefore, who are approaching the period of decline of life must be taught the physiological necessity of maintaining the condition of the general health at its highest standard in order to promote the "work of nature" employed in adapting the various structures and organs of the body to altering structural and functional conditions in obedience to the laws governing the incidence and progress of involutionary metamorphosis, and so to raise the barriers of physiological textural resistance and consequent immunity from the pathological attack of cancerous and other disease emissaries and enemies.

EXTRACT XLIV. B.

ON MATERIO-DYNAMIC PARALLELISM, OR ORGANIC CO-EVOLUTION AND -INVOLUTION OF TISSUE, ORGAN, AND FUNCTION, AS A NORMAL MODE OF DEVELOPMENT, OR GROWTH AND DECAY.

WE take it, as a physiological rule, that the development of structure, from the embryonic condition to the mature state, is accompanied by the development, or evolution, of function, in exact degree and proportion, or, in other words, that the *development of both is parallel or synchronous*, and that when maturity is reached both are characterised by absolutely normal, or co-ordinate, features and qualities, enabling their possessor to take a normal place in the battle of life, and to perpetuate the species, whatever it may be; any departure from this rule, therefore, introduces an element of friction, material or dynamic, into the physiological working and functional output of texture, organ, or organism, which, if persistent, must end in the production of a pathological condition or disease.

We contend that such an occurrence as *the loss of this parallelism* may give rise to a condition of disease, proportionate to the intensity and continuance of the cause, or causes, and becomes an absolutely provable fact, when we closely observe and consider the sequences of developmental events occurring in the evolution and involution of certain organs and structures, whose existence is maintained for a limited period of time in the life of the organism in which they occur, and whose functional activity is only temporary, or within more or less brief

physiological limits; and for an illustration of this contention, let us take the most prominent and outstanding example with which we have to deal in the human species, viz. the child-bearing period, and organs of reproduction, proper and subsidiary, of the female. The period of time embraced by the active functional working of these organs is represented by the years intervening between the age of puberty and the attainment of the menopause, and is of variable duration, due to the operation both of individual and general or climatic causes. During its continuance, great fluctuations, both in evolutionary and involutionary change, ensue from the exigencies of maternity—a consequent loss, or lapse, of parallelism preceding and accompanying them, especially the latter—which is the cause of many of the gynæcological ailments which ensue during this period of life, the rectification of which can best be effected on the lines thus indicated. In this connection we would observe that it is most remarkable, however, how often the human female, and more especially that of the *feræ naturæ*, performs the function of maternity, with absolute freedom from untoward circumstances, during any and every period of its duration—so precise and self-sufficient are the provisions of nature in all their details, a fact which warrants us in closely copying her methods and designs and adopting her plans, when called upon, in the exercise of our profession, to deal with such matters.

The cessation of the function of reproduction, and especially the attainment of the menopause, mark a period when a lapse of involutionary parallelism between structure and function may, and not infrequently does, take place, and where the lapse of function is, or may, for a variable period, be followed by a more or less appreciable continuance, or survival, of structure. Should this disparity be considerable in amount or extent, or long continued, the result will be a pathological condition, proportionate in extent, continuation, and intensity to the disparity. This doctrine applies equally to the uterine and mammary organs and subsidiary textures, and also applies with peculiar force to the incidence of disease in all organisms whose developmental history is one of

alternate activity and rest, rest and activity, a condition of things uniquely characteristic of the organisms of maternity. Thus, these organisms are embryonically and foetally developed with the rest of the bodily structures, and remain functionless, *i.e.* as to their specific function, until the age of puberty is reached, when they assume their functional rôle, which is characterised by periodic acute intervals of structural and functional increase, and diminution of evolutionary and involutionary development, until, their specific functional activity over, they resume the condition of the *status quo ante*. The resumption of this condition, of functional deprivation and organic rest, constitutes the occasion in the history of the individual in which the occurrence of non-parallelism between structure and function is most likely to occur, and where delayed material, or organic, involution of functionless textures is most apt to result in the production, or establishment, of pathological conditions — conditions which, if not capable of removal, must necessarily and inexorably lead to the production of either, or both, innocent and malignant disease. Here, then, we believe, we have reached one of those “points of view” in the evolution of self-originating, or non-conveyed, disease where the initiation and evolution of cancer can be observed, and its course seen as it pursues its fell way along structure and organ, destroying and annihilating every feature and outline of normal development, and reducing to one chaotic mass the fair physiological domain of harmonious proportion and good health.

As the active and specific functional rôle changes into that of rest, or stagnation, and disease, the structures, which have served their “day and generation,” are sometimes left to crumble into ruins, while the scavengers and refuse-removers for the time being are, for some reason or other, not called upon, or are unable, to remove the weight of functionless, or useless, debris; the formative, or organising, agencies in this pathological crisis take up the imposed, or sympathetic, rôle of performing the relinquished work, by covering up, ivy-like, the neglected material remains, by whatever material means may be at their disposal. This work, therefore, instead of finally

disposing of, or excreting, the crumbling and effete materials as they become devitalised, imprisons and retains them, thereby producing, or allowing to form, a pathological nidus for "new formations," from which dead or diseased materials are allowed to leak and well into the neighbouring functionally active body textures at large, to the detriment of the health, and finally to the death of the individual. That this can occur, in individuals of impaired, or originally low, vital resistance, with special readiness, is only too evident, and we hold that it explains the doctrine of the hereditary transmission of cancer, as well as some other reputed hereditary diseases, these hereditarily disposed individuals never manifesting symptoms of such diseases until their organisms become encumbered with functionless and perishing textures, with the removal of which their absorbing and excretory agencies are unable to deal—a feeble power of disease resistance, and insufficient ability to cope with tissue waste, being the inherited peculiarities on which these diseased conditions and pathological sequences of events depend for their origin and development.

The perishing remains of functionless and katabolic textures, must, therefore, be regarded as forming the originating and foundation physiologico-pathological basis, or matrix, on, and in which, the pathogenic agencies begin their malign work, and from which they attack and destroy the neighbouring healthy structures, making them "part and parcel" of their own malignant developments and textures; the nature and structural characteristics of these developments being necessarily coloured and determined by the organic materials on which they feed, and from which they are evolved and developed by the usurping pathological formative agencies and forces—no doubt dictated, or determined, so to speak, by the formerly prevailing physiological régime.

The *principle* and *working* of the *physiologico-pathological process*, or *succession*, of evolutionary and involutionary events in the life history of plants and animals alike has long been observed and studied, and is, or, we may say, ought to be, now recognised as a *universal law*, by the operation of which nature arranges and accomplishes her

work of organic succession in tissue, organ, and organism generally, as well as individually and specially, throughout the entire field of animated nature. Cancer, originating thus, may be regarded as an attempt to meet a physiological requirement on the part of the formative agencies, physiological and pathological, inherent in every human system, at a crisis in the organism where it is met with, and wherein, instead of levelling down and eliminating, dead and dying textural materials, these formative agencies in their *transition*, or *dual régime*, level up and imprison them in their transition condition, with the result that they become the prey of any wandering pathological parasites, or phagocytes, which may invade them, thus allowing such organisms to thrive and propagate and distribute themselves throughout every inter-space and cranny into which they can possibly find an entrance throughout the length and breadth of the unfortunate individual who may happen to be their host. It may, therefore, well be that the modern quest for *the microbe of cancer* may prove a rather disappointing one, on account, thus, of the possibility of the existence of a multiplicity of bacillary organisms which may each find congenial work and means of development and perpetuation in the soil of functionless and effete structural material, in its processes of physiologico-pathological change, and final transitional disposal. Cancer, consequently, *if microbic* in nature, is not necessarily so from its inception, inasmuch as the pre-existence and persistence of a down-grade metamorphic matrix of adynamic, or functionless, material is necessary for its starting-point, along with an initial play of pathological formative energy on the effete elements before their final relegation to the powers of disease and death, and their return to "dust and ashes"; it behoves us, therefore, if we would prevent this affection, to obviate such a concatenation of disease-permitting conditions, by adopting such measures as will accomplish their occlusion, or removal, and by securing the possession of an effective power of physiological resistance to the incidence of all such lethal pathological changes, through the use of means of elimination of sub-involuted and semi-disintegrated structural materials, and the "ordering into line," or

parallelism of working, of function and structure generally as well as specially.

Thus regarded, cancer must be understood as a *disease of the transition state*, or an affection which appears in structures, organs, or systems, whose textural and functional states are liable to more or less sudden disturbances at certain stages and phases of life, and when, in consequence, a non-parallelism, inequality, or disproportion, is apt to ensue between the hitherto harmoniously dual working of the physiological elements of structure and function. Hence, it is met with, more particularly in late, middle, and advanced periods of life, or when "in the nature of things" the laying down, or abrogation of function, necessitates, but is, unfortunately, not always immediately succeeded by, the removal of the now morbid structure, and the adaptation of the altering means to the altering ends—the *but*, in such cases, signifying the pathological "point of departure," where disease is liable to take the place of health, and marking the commencement of that shorter or longer downgrade progress which characterises the "decline of life" ere it merges into death, and final inorganic resolution.

The decaying, and, therefore, somewhat septic material, set free by the cancerous and other breaking down, and pathological resolution of functionally inert tissue plasma, invades by circulation the lumen of every vessel—be it blood, systemic lymph, or neurolymph—and traverses thereby, more or less, of the whole or related bodily structures; moreover, by histological continuity along the purely fibrous and other quasi-solid elements of the affected areas, it makes its way in a more circumscribed and limited manner into the solid matrix of the neighbouring structures and organs.

These views of the genesis of cancer and tissue disease, or malignant and innocent growths generally, would indicate that the processes of physiological involution merge insensibly into, and are continuous with, the processes of pathological evolution; or, in other words, that an unbroken process of growth and extension characterises the ending of the physiological structural régime in that of the pathological, no absolute or sudden line of demarcation being distinguishable between them, the elements

of growth and the vital forces involved at such junctures being one and the same, plus the addition of the modifying and determining morbid causes, or influences, be they chemical, bacterial, or dynamic and vital, or other. On analysing these statements for the detection of the underlying and pervading principle or condition, determining the inception of the pathological régime, we are obliged to acknowledge that we can see no other than that of the occurrence of materio-dynamic non-parallelism, or non-synchronicity between the removal of structure and the lapse of function, or the survival of non- or insufficiently vitalised tissue materials, whose functional rôle has been abolished, and whose removal has not been physiologically effected.

The physiological necessity for the removal of functionless tissues and organs is constantly occurring throughout the lifetime of the individual from the earliest embryonic state until the lapse of three score years and ten, or later ; and if constantly recognised by nature, and, it may be, aided by art and rigidly effected, nothing else, so far as this aspect of the occurrences which shorten life is concerned, can hinder the attainment of its "allotted span." In explanation, therefore, of the reported increased prevalence of cancer in late times, we would advance the opinion that our failure to recognise the truth of this contention, and to adopt means for its prevention, or neutralisation, has allowed to occur just those circumstances which encourage its origin and perpetuation, and which, if not attended to in the future, must of necessity still farther add to the price that is paid for modern civilisation, with its *increased labour-saving inventions, artificial arrest of muscular effort*, and over-indulgence in luxury. Moreover, we are of opinion that the adoption of measures of a preventive character, based on the indications deducible from these views, and used to supplement and perfect the physiological working of the natural organic agencies of internal hygiene, will do much to counteract and neutralise these predisposing influences and circumstances in their immediate and remote effects, and to that extent widen the boundaries of preventive medicine generally.

Internal, or organic hygiene, as we may call it, has been to a very great extent left to nature, or the *vis medicatrix naturæ*, and has had little or no attention bestowed on it until the failure of its health-preserving provisions have allowed the intrusion of pathological factors and the production of disease, when, alas! it has been too late to render effective assistance to these overpowered organic health-preserving agencies and natural hygiene. We would, therefore, reiterate the great necessity there is for modern life to be safeguarded by the adoption of a more rational means of prevention of such diseases as cancer and allied affections, seeing that curative means so far have not been so successful in their effects as the supreme requirements of the situation necessitate and demand.

EXTRACT XLIV.c.

ON THE PHYSIOLOGICAL PROCESS KNOWN AS "AGEING," OR INVOLUTION.

WE have already "trenched on this ground," but still think that it requires "turning over," in order that it may yield "something more of a crop" to repay the expenses of labour.

"Ageing" is a natural process due to the co-operation of dynamic and material factors on definite physiological lines, and characterised by the evolution of a regular succession of *tableaux vivants*, or living "tell tales," each indicating a difference from the other in physical features and physiological peculiarities sufficient to mark the stage of development and age attained by its subject in his or her passage "from the cradle to the grave." The process thus viewed reveals the great physiological truth that the limits of life—as represented in the usual experience of "the longest liver," or where and when senile decay takes possession of the organism and closes the life scene by involution—are laid in and constituted respectively by the two great periods of almost purely systemic nerve control, and the combined early and late periods of nervine control actuated by the influence of sympathetic nervine energy dominant during the almost entire abeyance, on the one hand, and final exhaustion, on the other, of systemic nerve energy.

Between the periods of pre- and post-sympathetic nerve control in the systemic period of innervation of the organism, we witness the continuous evolution of the representative phenomenon of "age" or "ageing"

impressing themselves more or less definitely on the *physique, esprit, et morale* of every descendant of Adam, and can, by observation and education, qualify ourselves to pronounce a more or less true and definite opinion upon the life history of any one of these descendants.

The abstract scientific importance of thus being able to read life history is very great, and daily becomes greater as the relationships of "man to man" widen and accumulate. It, therefore, becomes necessary that the "fundamentals" of the art should be laid on a basement of exact knowledge of the "subject matter," and a scientific appreciation of the factors involved, in order that it should take its place as an accessory instrument for the discovery of truth and a supplementary instrument for the advancement of civilisation, without suspicion, on the one hand, and with that warranty which such an instrument and weapon must possess whenever used in the regulation or administration of human affairs, on the other.

In examining in some detail these "fundamentals," we have become aware that the phenomena of "ageing" are more or less intelligently read and understood, and "acted upon," not only by uneducated man, but by the whole animal, and even, to some extent, the whole vegetable world, and that, therefore, they constitute, in fact, a large part of the great generalisation known as the "law of natural selection," as it is revealed to the organic world. The occurrence of "ageing," as here indicated, may be described as, in great part, innate, and the production of heredity, impressed on the succeeding generations of organic forms, and transmitted with them for purposes of organic evolution, racial progress, and differentiation. It thus becomes one of the most universally possessed attributes of organic life, and consequently an instrument for the moulding of organic destiny, on the lines of organic evolution, of the most all-pervading character and nature. In the human species, with which we are more immediately concerned, "ageing" lays its hand on every structure and organ of the body, and every feature and trait of the mind and character, overrunning and inter-penetrating the very "weft and woof of life," and maintaining a *consistency of plan*, in spite of all the alterations of environment of the

individual, and the variant combinations of evolutionary influences to which the individual, as distinguished from the community, may be subjected. Ageing is thus confined—"all things being equal"—to a *finely graduated range of incidence* in every tissue, organ, and texture of the individual body, and is consistently impressed as to rate, extent, and conspicuousness on the *tout ensemble* of that body as well, so that a regular rhythmic progress, so to speak, is the result—a result so regularly recurrent and "plain to behold," as that "he who runneth may read," so that thereby mankind is saved the trouble and embarrassment of putting direct questions, which have sometimes both a negative and positive bearing at the time, which it is usually politic to avoid, and which, moreover, is not usually required for scientific purposes.

Ageing impresses itself on the whole anatomical elements of the body, simultaneously making itself felt in and on these elements, in accordance with the character of their structure and their altering conditions as to exercise and nutrition, as the race of life continues to be run, and as the effects of "tear and wear" on them become more and more *felt* with the passage of time, the natural clinging to the body of disengaged material, and the physical cohering of disintegrated or metabolised material, to the functionally living and active structures.

Ageing thus viewed covers a very large field of anatomical and physiological physics and dynamics, a field so large, indeed, that we here can only touch the fringe of it; that fringe, however, embodies some account of the intrinsic changes presented by the skin and subcutaneous textures, or those personal characteristics more especially "visible to the naked eye," and, therefore, easy of access to everyday clinical experience and physiological observation.

The skin and subcutaneous structures are continually undergoing changes, many of which are so unapparent and gradual as not to attract attention, and many so instant and acute as immediately to arrest attention, and become the theme of interested thought and dialogue between subject and bystander, and, it may be, to afford a thesis for physiological consideration and elaboration on the part of some who, by special training, have had their scientific

“wits sharpened,” and their scientific curiosity aroused to the requisite degree, to enable them to undertake the recondite task.

The degrees to which the respective elements of the skin and subcutaneous tissues are developed, and the proportions in which they are admixed in infantine, adult, and senile age respectively, constitute the basis on which the phenomena of ageing are mainly determined, and the material out of which they are evolved, as “time goes on,” by the operation of physiological law on anatomical elements and in anatomical order. Thus, the infantine skin is, or may be said to be, predominantly hæmal in its vascularity, the skin of adult life to be of a predominant neural vascularity, in which the *tactus eruditus* is, or can be acquired, and exercised in perfection, while the skin of the senile is passively hæmal, and retrogressive changes make manifest the reversal to the hæmal type, each conspicuous area of hæmal vascularity remaining in somewhat solitary grandeur amid the disappearing remains of the neural vasculature. It should be added that, amid all these vicissitudes of cutaneous vascular change, the systemic lymph vasculature undergoes a greater or lesser structural change also, but not to the extent or in the degree that characterises either the hæmal or neural vasculatures, and, therefore, that it has not the relative importance as an ageing factor that belongs to either the hæmal or the neural vasculatures, and may be allowed to lapse from our further enquiries into the subject, except so far as its temporary passive attitude in certain pathological conditions is concerned, as, for instance, in œdema and anasarca. The consistence and depth of the skin and subcutaneous tissues, together with the amount of anatomical subjacent packing or padding, determine, to a great extent, the smoothness or the reverse of the cutaneous surface, and hence, to a considerable extent, “stamp” the various stages of the process of ageing. The earlier periods of life, being characterised by greater fulness and consistency of these tissues, are devoid of the wrinkling of the later periods, and hence give to them that appearance of youthfulness so pleasing to the eye of the æsthetic, and so fruitful of poetic “inspiration” in both sexes of the human race, and this is, no doubt,

fraught with great potentialities for the furtherance of nature's plans and the accomplishment of nature's work.

Consistence and depth of skin and completeness of underpacking being chiefly responsible for the regulation of the incidence of surface ageing, it follows that that incidence must be determined by the changing proportions of these elements to each other, and by the altering proportion in anatomical space they occupy with relation to the deeper-seated structures during the various stages of the process.

The skin being mainly made up of two vascular elements, whose circulatory vascular phenomena are entirely different the one from the other, it behoves us to analyse to some extent the character of these phenomena, in order to arrive at more exact and definite ideas than we have hitherto held with regard to the rationale of external ageing.

Leaving out, still, the lymphatic circulation of the structures involved, as not decidedly necessary in the following analysis, we would premise that there are two circulations involved in particular in the process of external ageing, one hæmal and the other neural. The first, or hæmal, is a circulation through an arterial vasculature ending in a capillary network of intermediate minutely divided and anastomosing vessels, where the phenomena of hæmal change from arterial into venous takes place, and where the venous vasculature re-collects, for renewed arterialisatation, the minutely broken up capillary currents. In this circulation there is no excretion of the hæmal elements into the cuticular textures through which they pass save those of metabolism, and, consequently, no macroscopic deposit in the matrix of the skin, and no material shedding, which on "setting" can add to its thickening and consistence, or depth, the circulation being into and out of the anatomical elements of the skin, with the secured freedom and hydraulic strength and completeness of an uninterrupted current, perfected by ubiquitous capillary vascular anastomoses and open capillary channels. This circulation, the hæmal, we must, therefore, eliminate from the "possible" agents in the process of ageing, at any rate in so far as it can be held responsible for the increasing

consistence and thickening of the skin, and for those features of cutaneous change evolved by age. Having thus disposed of hæmal circulation as an appreciable genetic influence in the process of external ageing, we are left with the neural circulation to account for the physical changes undergone by the skin, and thus to become the chief instrument in producing and meting out the specific signs and memorials of ageing.

The neural circulation, as we elsewhere have described, is a compound circulation, consisting of, at least, three distinct circulations, all of which have one feature in common, viz. that they *end* in and on the skin, and terminate by the excretion of their entire circulative materials, according to their specific or intrinsic characters as to fluidity, plasticity, and physical qualities generally; thus, the neural lymph circulation terminates immediately in and by the sweat glandulature as a fluid, or gaseous and evaporable, material, or excrementitious substance, while the medullary and the axis cylinder substances of the axons lend themselves to the histological increase or growth of the dermal and epidermal textures, and thereafter to gradual exfoliation, or shedding, as more or less solid exuvix.

The first of these neural circulations, the neural lymph circulation, may, like the hæmal and lymphatic circulation, also be eliminated from the list of agencies primarily conducive to the process of external ageing, inasmuch as it is concerned in transmitting *through* the cutaneous structures a fluid and non-plastic element, which in a normal or physiological state leaves no trace behind, but which, in certain pathological conditions, lends itself to the conveyance, in suspension, of morbid elements which may undergo changes in transit, rendering them, more or less, permanent ingredients of the dermal and sub-dermal structures, as, for instance, in certain forms of gout and rheumatism, and other allied affections.

This elimination of all the local circulatory elements concerned in the vital work of the skin, with the exception of the two outstanding neural, or neuro-axonal, circulations, whose final outfall work, or excretional disposition, constitutes, in great measure, the active functional *raison d'être* of the skin with its appendages, compels us to adopt the

opinion that these two neural circulations, the medullary and axis cylinder, are almost entirely responsible for the production of external ageing, and, therefore, that the varying rates of their terminal output or discharge constitute the main factor in the evolution of the physical and physiological changes engaged in marking out the stages of external ageing, and the sequence of cutaneous change, during the entire span of life. These two circulations, *being from centre to periphery only, cannot return* the substances they are respectively circulating to their sources of origin, or to a common radiating centre, as the hæmal circulation does, or secondarily find their way into the hæmal circulation, as the systemic lymphatic circulation does; they, therefore, being histologically free at their distal ends, are compelled to expend them in the development of dermal and epidermal structures and appendages, to be ultimately shed, or finally liberated, by external exfoliation, after a shorter or longer incorporation in surface, as well as deeper-seated layers of the skin. Hence, they become the principal sources of dermal and epidermal growth, both in a material and dynamic respect, and so they are the almost entire sources of surface, dermal and epidermal, modification, and the prime factors of external ageing, as well as the structural source of origin of many of the pathological conditions of the skin, which are liable to arise at all periods of life, mainly from faulty excretion or exfoliation, and deficient or redundant circulation.

The depth and consistence of the dermal and epidermal matrix, being principally regulated by the rate and amount of the neural incorporation and excretion, varies in amount at every stage of life, according to the degree of physiological activity and freedom from mechanical obstacles characterising the functional, or vital, working of the individual organism. From this it follows that the depth of the "wrinkles and lines" of ageing is determined by neural circulation, deposition, and excretion in, and of exfoliation of and from, the cutaneous textures, and their character as to intensity and natural sequence impressed on their subject in more or less easily read type.

Besides the surface markings of age left on the external envelope of the body, the appendages of the skin, more

especially the hair, undergo changes of pigmentation, which afford a very apparent and outstanding index to the period of life reached by the individual, and, to some extent, of the character of the life experience passed through. Moreover, these pigmentary phenomena seem to depend for causation on influences operating through the neural circulatory media, chemically and physiologically, and represent, in sequence, the causes composing ageing, synchronously with the other surface signs.

It may further be said that baldness, so widely prevalent and conspicuous in the present age, represents a failure of the inner neural circulations to reach and sustain the growth of the hair bulbs and shafts, while the hæmal circulation not being fully utilisable for the purpose, the inevitable result is the failure of the hair growth, and the consequent death and disappearance of the hair structures, with atrophy and attenuation of the hair follicles, to the extent that no recuperative procedure is, or can be, attended with other effect than disappointment to those who try them. The occurrence of baldness must, therefore, be anticipated, and the precipitate occurrence of down-grade changes prevented, in which case there seems hope for the retention or preservation of the hair, for a time at least; but here it is necessary to indicate, that preventive treatment to be successful must be carried out on absolutely scientific and non-empirical lines, and with a continuous determination to maintain the vital activity which nature is showing signs of inability to sustain, and which, in time, she will be compelled to abandon, or modify, in consonance with related changes as general ageing proceeds, and as the process of physiological involution becomes more and more complete.

Besides the changes in pigmentation and growth observable in the skin and its appendages as ageing advances, a graduated series of changes is undergone by its epidermic layers, more especially of the hands and feet, which "tell the same tale" as we have here been endeavouring to "unfold." Confining our remarks to only one detail of the subject, that of the "ridging" of the palmar and plantar surfaces respectively of the terminal

phalangeal extremities of the fingers and toes, we would state broadly that these "ridges," and their intervening "furrows," while maintaining exactly the same ground-plan, barring changes due to accidental alteration and obliteration, alter at different periods of life in their proportionate height and depth. Being intimately related to the sense of touch, they change in their manner of accentuation with age and occupation, being at one age and another more prominent, in proportion to local necessity and the special education and wants of the individual, as well as in proportion to the amount of peripheral nervine material deposited in, and exfoliated or shed by, the digital nerve terminals. Digital ridge and furrow development waxes and wanes with the phenomena of systemic or organic evolution and involution, culminating with the attainment of the former, and gradually declining with the advance of the latter, showing, however, considerable divergences in incidence, generally and locally, determined by general and local nervine conditions and circumstances.

These things must, therefore, be borne in mind in connection with the possible medico-legal bearings of the subject. Thus, in advanced life it is frequently observed that the little, ring, and outer half of the middle fingers show signs of effacement of the "ridge and furrow" surface characters, long before the thumb, forefinger, and the remaining half of the middle finger show any signs of failure. The explanation of this inequality of effacement incidence would seem to depend upon local nerve distribution, along with the greater necessity for a more prolonged extension of tactile acuteness by the latter digits, and the consequent continuance of greater determination of epidermal material towards these more frequently used and acutely sensitive surfaces—on the principle of *ubi stimulus ibi fluxus*—proving once more the truth of the contention that acuteness of innervation and the maintenance of the circulation of neural pabulum are always coincident and proportionate.

In association with the incidence of "ridge and furrow" effacement is atrophic change in the bulbous extremities of the affected digits, whereby a more or less phenomenal

subcutaneous shrinkage takes place, resulting in the production of a marked longitudinal skin "creasing," with less obvious transverse cavo-relief marking, after, to some extent, the fashion of the washerwoman's fingers when long immersed in soap and water.

All these changes may be regarded as involutionary, and the outcome of nutritive shrinkage of the episkeletal, or soft, tissues surrounding mainly the terminal phalanges, but likewise also of those of the whole limbs, and trunk especially, or those innervated and *fed* by the systemic nervous system.

EXTRACT XLV.

ON BODY TEMPERATURE.

THE normal temperature of the human body is now generally understood to be 98·4 Fahr., and any considerable or continued departure from that standard is to be looked upon as the outcome of some pathological condition of one or another part, or of the whole, of the bodily structures. The regular maintenance of this degree of temperature must, therefore, be looked upon as due to the balanced action or operation of the various forces and forms of energy belonging to that body, in its equipoised physiological condition, on the materials, solid, liquid, and gaseous, which find an entrance into it, plus what is due to the voluntary exercise of any or all of the organs and structures under the control of the will.

Thus physiologico-chemical changes, comprising those of composition and decomposition, and the synthetic and analytic metabolic activities, with the expenditure of nerve and muscle energy and its attendant molecular disturbances, besides what, over and above these, remains of the *now vanishing* "vital work" of the economy generally, make up the series of heat producing and supporting agencies, which go to maintain a temperature of 98·4 F.

So long as the contributions of caloric from these various sources are neither more nor less than the physiological standard necessitates, the natural degree of 98·4 must be the result. So soon, however, as these from any cause or causes become disturbed or uncertain, the temperature suffers a rise or fall, as the case may be, with a consequent lapse into a pathological condition, which

condition must necessarily be dependent on, and determined by, the character and cause of the increase or diminution, and of the particular part of the calorific machinery involved in the particular instance.

Thus a state of fever may be due to an increase in the quantity of caloric contributed from one or more of these sources, while a state of collapse may, in like manner, be due to a lessened contribution, the various degrees of increased and diminished temperature included between these extremes being similarly determined.

As a matter of everyday clinical experience, however, we find it difficult to apportion, with any degree of exactitude, the sources of increased or diminished temperature, and so have to be content with an approximate attempt at a solution of the complicated problem, and a correspondingly empirical choice and administration of our ameliorative and curative agencies, medicinal and others.

The state known as fever, or pyrexia, being due to one or more causes, the sources and nature of which it is of the greatest importance to determine, let us endeavour to give an example of our course of procedure in arriving at a solution of the problem by the choice of the simplest known example of the condition, viz. febricula.

Febricula is a somewhat variable affection, both in its intensity and duration, and arises, culminates, and declines often, or generally, without the necessity for any intervention or alarm; being, consequently, not *often seen*, but *sometimes experienced* by those competent to draw scientific conclusions regarding it, convalescence ensuing through the untrammelled and unadulterated operations of the *vis medicatrix naturæ*. The disease is usually ushered in by a more or less pronounced sense of "chill," succeeded by a more or less sustained rise of temperature, with a varying amount of functional or organic derangement or disturbance, and is succeeded by a shorter or longer period of recovery or convalescence.

The sense of "chill" may be induced by the operation of various causes, such as exposure to cold or wet, or cold and wet, and consists of the excitation of the vasomotor nerve mechanism of the skin, with the contraction of its muscular mechanisms, the closure of the ducts

of its sweat glands, producing, it may be, the condition known as "*cutis anserina*" and the hæmic depletion of its surface layers, with the consequent and proportionate, more or less appreciable hæmic repletion, of one, more, or all of the deeper-seated parts. This, the initial stage of the morbid process, if it can be so called, lasts for a somewhat indefinite period, when it is succeeded by a more or less pronounced reaction, consisting of a more or less profound disturbance of the whole "internal economy," with a greater or lesser exaltation of temperature, constituting the fever, febricula, or pyrexia, which, in turn, lasts for a somewhat indefinite period, or usually until the sweat glands have been unlocked and diaphoresis established.

In analysing these events, and noting their sequence, we are struck with what seems to us a "casual relationship" running through and connecting them one with another; thus the "cold and wet," acting as the initial influences in the production of the morbid phenomena described, are instrumental in procuring the closure of the channels by which surplus caloric is discharged through the external surface of the body, and so, in arresting its radiation and regulated dissipation, and procuring its consequent and proportionate retention and accumulation within the body; primarily, therefore, the increase of temperature in this instance is due to retention, or non-discharge, of caloric; secondarily, however, it may be increased by physical, chemical, and biological action, exerted by the detention within the body of noxious and actively anabolic and katabolic materials.

Summarising these remarks, we may describe febricula as a morbid condition, due to retention of caloric from closure of the channels of radiation, with a consequently increased amount of metabolism, and requiring for its removal the spontaneous, or artificial, reopening of said channels—the whole diseased process in its initial, culminating, and closing stages, consisting of merely a mechanico-chemico-physical disturbance, and its subsequent subsidence leaving "not a trace behind." We may here remark that a temperature of 98·4 F. can only be maintained by a regulative machinery, which is

possessed by every human body in a state of health, and the disturbance of which leads to a rise or fall, as the case may be, or to the development of a more or less prolonged pathological departure from the normal temperature. The basis of this regulative machinery is, we conclude, located in the skin externally and the air-passages internally, whose outlets, open or closed, are regulated by nerve and muscle, agencies which determine the proper amount of insensible transpiration and sensible perspiration and respiratory output respectively passing through them, and, so long as the conditions of health are maintained, sustain the standard of the body temperature at 98.4°F . Thus, we find that a healthy human body *in a state of rest*, does not require the free opening of its cutaneous apertures, provided a suitable temperature of its environment prevails, hence we conclude that the ordinary external and internal *radiation* suffice to maintain the natural, or normal, 98.4°F . We find also that a human body *in a state of activity* requires, for the maintenance of 98.4°F ., a more or less free exercise of the functions of *transpiration* and *perspiration*, in addition to that of ordinary internal and external *radiation*.

The general cutaneous surface of the body is constantly, more or less, employed in this function, and is to a great extent, although not by any means totally, sufficient for the vital function of heat or temperature regulation, the mucous and certain serous surfaces, as well as gland textures, being also largely utilised for the same purpose. Radiation is constantly, therefore, in evidence from the surfaces of the body, wherever they are reached by the surrounding air—whether that air is above or below the temperature of the body in question—hence radiation is a relative process, being regulated to a great extent by the prevailing surrounding and inhaled air, or external atmospheric temperature; besides, it seems to us not to be regular or identical in its amount throughout the area or extent of its occurrence, but to prevail to a fuller extent over certain areas in particular, such as, for instance, the palms of the hands and the soles of the feet, which, being usually exposed to contact with relatively cold surfaces, radiate their heat much more rapidly, in conse-

quence, than the general surfaces. It, moreover, seems to us here, that caloric is much more largely and rapidly transmitted along the nerve trunks of the limbs, than through their general structures, or substance, and that the warmth of the hands, so often and almost regularly experienced by many, is due to its correspondingly rapid escape, or discharge, through the terminal nerve arborisations, sudoriferous channels, and epidermic surfaces of these parts; and thus may be explained the why and wherefore of such enigmatic occurrences, as the simultaneous existence in the same limbs of "cold knees and hot feet," the deeper nerve trunks being in such cases utilised for the passage of *under-currents* of caloric from the central to the peripheral regions of the body without, necessarily to any perceptible extent, influencing the intermediate overlying regions—consequently, nerve trunks, with their terminal extensions, constitute, so to speak, an ideal ready-made and continuous mechanism for the conduction of caloric, its distribution, and, if necessary, its discharge, so as most readily and effectually to secure the maintenance of the required standard temperature. Any solution of continuity of this mechanism, therefore, constitutes a grave danger from the point of view of its importance as an instrument for the regulation of body temperature.

In performing this function we may regard the whole textures, constituting and immediately encircling the whole nervous system, as lending themselves in greater or lesser degree to the accomplishment of a common object, the circulation, the equal distribution, and disposal of the common stock of caloric, and the consequent maintenance of a regular temperature—all which it accomplishes, no doubt, in conjunction and collaboration with the blood circulation, the one, in many cases, substituting or supplementing the deficiencies of the other, not only in the disposal of *caloric*, but in supplying some of the *materials* required in gland secretion and excretion. Thus, the sweat glands, the nasal mucosa, and Bowman's glands, the lachrymal glands, the salivary glands, the pituitary gland, the coccygeal gland, and many other glands, as well as the lymph channels pervading the eyes and the

ears, which may be regarded as deriving their lymph supplies principally from cerebro-spinal sources, supplementing them when and where necessary from the adjacent blood circulation through its liquor sanguinis, and expending them in a regulated outflow, all which is accompanied by a regulated escape of caloric and consequent steady maintenance of the body temperature.

Circulation in its widest sense we thus realise embraces every variety of circulation, material and dynamic, which has been observed in action throughout the living fabric of the body, and constitutes at once an almost ever ready and available means of maintaining the temperature of that body at a constant degree—we say, almost ever ready and available, because occasionally there occur intervals of disturbance when morbid influences are at work begetting pathological elevations, or depressions of temperature, according as the means of escape, or imprisonment, of caloric are provided, and according to the extent to which the powers of natural adjustment have been affected.

Amongst the circulations referred to, as operative in the regulation of body temperature, we must include the circulation of energy, chemical, vital, nerve and caloric, in fact, all forms of force involved in and flowing from functional activity.

By these various means of upholding and sustaining a regular, or mean, temperature, the living body has at its disposal an “array of choice,” so to speak, of a very complete and varied character, by which the *vis medicatrix naturæ* is enabled successfully to assert her powers amid the most changeful surroundings. The increase or decrease of body temperature beyond the degree of 98.4 F. is most jealously regarded by nature, and the requisite means of adjustment being almost always available she is almost constantly able to maintain the requisite equilibrium; but if perchance an accident occurs to modify, or destroy, these means, she, if the life be still sustained, begins along the lines of action still remaining to her to remove the effects of the accident with its consequent “wreckage,” and to effect the work of the readjustment of these means and the restoration

of the mean temperature. The other great means, viz. the process of respiration, of allowing the escape or discharge of caloric, and of regulating body temperature, might be described a little in detail. The air passages of the human body, and of those of the mammalia generally, comprise the nasal passages, including the pneumatic spaces of the face and head, the mouth, the pharynx, the larynx, the trachea, the bronchial tubes, and the pulmonary vesicles—surely a list of anatomical spaces of great variety and complexity, and comprising at once a series of pneumatic tubes and chemical chambers, where, besides facilities for gaseous diffusion and chemical reactions, a caloric adjustment apparatus is provided, which, acting synchronously, and in concert with the other means of adjustment, plays an important part, perhaps *only second* to the skin, in the maintenance of the standard of body temperature. Here, in the “regions of calm,” amid the air spaces of the face and head and throughout the narrow but wide expanse of the minute bronchial and vesicular spaces of the pulmonary organs, unaffected by the exigencies of respiratory effort, where the *residual air* “*lingers*,” we have an ample theatre adapted, the means provided, and every facility afforded by which, besides chemical interchange, the great function of caloric disposal and regulation can be effected with exactitude and safety.

The maintenance of a mean, or standard, body temperature by the disposal of surplus caloric, and the equal distribution of cerebro-spinal lymph or fluid being accomplished by the synchronous and duplex working of the same machinery, acting in its double capacity of caloric discharger and lymph circulator, the proper adjustment and working of this machinery, therefore, become a matter of the greatest importance in disease.

Force and matter, in their inter-dependent relations to each other within the living body, circulate through the same channels, work by the same mechanisms, and when kept within normal limits, yield the highest results, and perform the best work for their respective and combined materio-dynamic expenditures.

EXTRACT XLVI.

ON SLEEP.

SYSTEMIC nerve force cannot be continuously discharged by the nerve-force-producing agencies, and the process is, therefore, interrupted by repose or sleep, in which both the wasting results of material tear and wear and dynamic loss are made good, and the storage capacity, material and dynamic, of each neuron, and system of neurons, renewed and secured in equipoised and non-explosive proportions, the empty or exhausted being, it may be to some extent, supplied from the full, or plethoric, and a non-explosive medium, and smoothly working condition maintained. Thus the continuance of the power of sustained brain work is secured by periods of redistribution, as well as reproduction of nerve force or energy, and by the removal of waste or effete material products, and the supply of fresh materials to take the place of these waste or effete products during the daily recurring intervals of sleep, when the presiding ego itself retires for some repose behind the barriers of its material impedimenta, *inhibited* for the time being from the world of sense and time by the idle and exhausted machinery which it has ceased to animate from the lack of nerve energy or power and the accumulation of disintegrated matter.

During the intervals of sleep the psychic, sensory, and motor neurons cease working, while the sympathetic, or truly trophic, nervous system continues active, directing the removal of debris, laying down new materials where required by the incidence of waste, and "burnishing up" the complex machinery of the whole vital, but more

especially systemic, nerve organisms. Moreover, during these periods of sleep, and of course the "sunder" physiologically they are the better, nerve energy, where it has been over-expended, is renewed, if not by regeneration, by the re-distribution of the unspent energy of the idle and surcharged neurons, thus relieving the latter of any unneeded explosive or potential energy, or what is unrequired for their immediate functional needs, by transferring it to the exhausted and force-expended neurons, which have been "bearing the work and worry of the day."

Sleep! What is sleep from this point of view? It is the cessation of conscious cerebration and the controlled expenditure of nerve energy, whether in "thought, word, or action," *i.e.* of the intellectual, sensory, volitional, and motor modes of nerve energy brought about by the exhaustion of that energy, in whole or in part, or by the material or mechanical clogging of the generating, regulating, and expending machinery, due to more or less intense, or prolonged, action and wear and tear, and in consequence, it may be, of auto-toxis, or intoxication, begotten of the accumulation of effete toxic and mal-active substances, and *a consequent temporary paralysis cerebri*.

We again ask, What is sleep? That is a question which has aroused the curiosity and baffled the oft-tried ingenuity of the human mind in every generation of the race, and which still awaits an answer. The presumption, or assurance, therefore, involved or implied here, in again attempting an answer, may perhaps be excused on the ground of the attempter's possession of the usual, if not an abnormal, curiosity, and a desire, if possible, to add a little more to the modicum of truth which has already accumulated on the subject.

Sleep may be further described as the cessation of the function of active, or physiologico-psychological, cerebration in its complete systemic aspect, due to the operation of an inherent property and process of inhibition possessed by the individual and collective neurons, or to the existence in the neuronal commonwealth of a self-regulative and inhibitory machinery; or, it may be, to a combination of individual and general neuronal inhibitory systems, one

or other, or both, of which may be in use, according as the sleep is shallow or profound, the former being exemplified in the states of dreaming, and the latter in the dreamless sleep of great fatigue or exhaustion. Exhaustion of the nerve energy production, which, under ordinary circumstances, supervenes once in the twenty-four hours, usually synchronising with the "day's decline," determines the process of inhibition under the normal physiological conditions, the material waste entailed in the day's cerebral work and the neuronal output, the lost, or spent, energy and the material waste being commensurate with, and representing respectively, the amount of dynamic expenditure and material loss or displacement. As to how inhibition of the process and the machinery of cerebration is effected we must confess to a want of tangible evidence and proved data whereon to base more than the slenderest inference; nevertheless, taking advantage of what little tangible evidence and data we have, and straining the modicum of inferential light on which we can legitimately lay hold for the purpose, we think we are warranted in offering the opinion that it is effected in some such way as the following:—Up to the present the "weight of evidence" favours the view that the neuron is an independent unit histologically, but that it is in contiguity with its neighbouring neurons so intimately that, for combined functional purposes, it is virtually in continuity through mutual dendritic contact, the dendrons being possessed of the power of amœboid movements whereby they can be projected and retracted. From this we would infer that the projection, or extension, of these neighbouring, communicating processes or dendrons coincides with the period of co-ordinated cell or neuronal activity, and similarly that their retraction or relaxation coincides with the period of cell rest or unicell activity, and that these processes, being more or less in active exercise during the period of the "waking day," become exhausted, and require rest, and, therefore, on the withdrawal of all stimulus to further exertion they become for the time being permanently and systematically released and withdrawn for, we may suppose, purposes of material nutrition and renewal of cell energy. The

process of retraction or withdrawal of the communicating dendritic processes of the neuronal commonwealth may be said to resemble what ensues when a countless crowd of "expanded" umbrellas are "drawn down" after a "deluge of rain"; we would claim, therefore, that this not only synchronises with, but that it is productive of, the inhibition of the process of cerebation, and consequently the *cause of sleep*. We may further infer that, with the growing exhaustion of the cerebral, and other nerve-cell, energy from continued exercise, the dendritic processes naturally become disposed to droop from the lowering supply of energy, and hence finally withdraw from immediate contact with each other and with neighbouring dendrons when the act of inhibition becomes an accomplished fact and sleep reigns supreme.

Meantime the sympathetic nervous system enters on supreme control of all the vital processes and work of the body, restoring, after sleep, to the systemic nervous system, the control of its own particular work, with its machinery burnished up and repairs effected where required, as well as with its nerve energy renewed and made capable of lasting out another diurnal "spell of work." Sleep, therefore, is a thing of the systemic nervous system and by the systemic nervous system, not involving the sympathetic nervous system, except it may be by an increase of work, nor *directly* the sanguineous circulation, although *indirectly* that circulation is largely involved, as providing the materials from which the nerve protoplasm is renewed and maintained, as well as much of the lost nerve energy obtained.

In this collection of neuronal dendritic phenomena is bound up the most cryptic part of the mysterious union of mind and body, of the ego with the non-ego, as well as the mechanism of consciousness; besides, in this *multum in parvo* physico-mental region, we are in touch with the supreme physiologico-psychological problems, in the solution of which are involved the destiny of man, mental and physical, with all that is involved therein and flows therefrom. It will thus be realised that, on an absolutely true physiological working of these minute and uncountable textures, depends much of the health, the

happiness, and the personal success of life, as well as the solution of the greatest of all mysteries, the destiny of the immaterial and indestructible ego in its relationship to the great "beyond."

Sleep may be said to be "sound" when the whole mechanism of consciousness is in complete abeyance, and to be "disturbed" when any part of that mechanism is in activity from any cause; in the former of these conditions we may take it that the whole neuronal elements, with their related and relating contiguous dendritic extensions, withdraw themselves into a state of individuality so complete, as to render their united action impossible, and, therefore, the resulting sleep is sound; in the latter, in like manner, we may take it that one or more of the neurons, or it may be a group or groups of neurons, remain or become contiguously related, and, therefore, active, and so result in the state of sleep becoming disturbed. The latter condition is that in which "dreams," "talking," and "walking in sleep," and other bodily movements take place, the condition itself being due to, or resulting from, the non-inhibition, or the defective inhibition, of one or more of a group or groups of more or less related neurons, psychic, sensory, or motor. If the dreams be elaborate, consistent, and well remembered, we may regard them as the product of grouped neurons; if not, then we may infer that the neuronal area implicated is proportionately smaller, and, when absolutely no memory of the dream cerebration is left, we may further infer that the leakage of nerve energy has been almost nil. The motor neurons are affected in like manner by, it may be, the primary motor determination or automatic discharge or escape of motor nerve energy along, it may be, much frequented paths, and on a considerable scale, or to single muscles, or groups of muscles, according to the degree in which the motor phenomena are manifested, and to their manner of combination and co-ordination. All such phenomena, therefore, whether purely psychic, sensory, or motor, are due to faulty inhibition or undue instability of the nerve energy storage mechanisms, or both, it may be, in certain individuals and in certain conditions of health.

Sleep is thus an absolutely physiological condition, and its incidence is due to the operation of physiological factors, these factors being confined, in their range of incidence and influence, to the specific histological or neuronal elements of the systemic nervous system, and the dynamic activities of that system, to the end that cerebration in its full and true sense should, or might, be maintained at its highest and most sustained and effective pitch or level; in other words, to borrow a "working" simile, it *constitutes* the *period of rest* for the neuro-systemic manufactory or industry, to *let off* steam, clean and oil machinery, remove debris, re-stock with fresh raw materials, and again *get up* steam. It, therefore, comes between the ego, or central immaterial essentiality or essence, and the sympathetic nervature or vital materio-dynamic essentiality, with a range of temporarily functionless materio-dynamic neuro-muscular structures, which effectually bar united, active, and co-ordinated cerebration, including sensory and motor activities, and intelligence in all its phases, excepting during incomplete incidence and dreams in all their varieties.

We are warranted, therefore, in inferring that total cerebro-spinal temporary paralysis or inhibition, on which sleep is dependent for its induction and continuance, coincides with, and is due to, a solution of continuity or contiguity, as the case may be, of the nerve cell processes of the purely psychic or mental higher systemic, and the cerebro-spinal neurons generally, and ceases when that continuity or contiguity is, or becomes, re-established. It is rhythmic in occurrence, coinciding or synchronising, in the human species generally, with the "day's decline," or onset of darkness, and terminating with the dawn, or from when the stimuli of light and sound are withdrawn, and the "silence of nature" is established, the sensorium then losing its receptive and responsive, or sensory and motor, powers, until they are renewed; in the lower animal and vegetable worlds, however, a greater variety in the incidence of sleep takes place to a great extent, apparently due to the acquirement of habit and the requirements of environment.

The length of its duration is as various as the

individual units of the human race, but, generally speaking, it may be said to vary between a sixth and a third or more of the twenty-four hours, or complete day; throughout the rest of animated nature its length and intensity both vary indefinitely according to the "law of necessity." Sleep may be called the counterfeit of death, and daily illustrates the occurrence of *discontinuity* between the higher materio-dynamic and neuro-intellectual elements of the body corporate, and shows their powers of separate or independent existence and of re-amalgamation. Inasmuch as the existence of the ego is not realised during sleep, and its necessary continuance or existence is undeniable, we are, moreover, entitled to maintain that it is capable of a separate or independent existence, and that the doctrine of *immortality* is warranted by psychologico-physiological science, based both on observation and experiment, so universally assented to, that a denial of its authenticity becomes possible only to those who refuse to accept evidence, and prefer to see nothing but *annihilation* as "the solution of the whole matter."

Law, whether physical, dynamical, or metaphysical, being absolute in its sway and inexorable in its incidence, and because so far as science has yet pronounced she has refused to accept of the doctrine of *annihilation*, she must necessarily, sooner or later, pronounce herself in all spontaneity in favour of that of *immortality*, and what a change will then come over "the spirit of her dream"? and the outlook on human life and destiny?

EXTRACT XLVII.

ON THE BLOOD—WHAT IS IT? AND WHAT DOES IT DO?

THE theme expressed by these words is, of course, far too extensive and arguable to be compressed into less than volumes, and too wide-reaching to come within the purview of any mere essayist. We therefore, in approaching the subject, merely intend to make out a few of its more salient features in "bird's-eye view" manner for biologico-topographical purposes, so to speak, so as to be able to fit it into the general plan of our already executed *sketch-and-patch-work*.

The blood may be described as the great central organic and inorganic fluid emporium of the body, into which enter the pristine or fresh nutritive pabulum as transmitted from the alimentary canal, and the residual lymph or waste material gathered from every tissue and structural component of the living and working organism, conveyed hither by appropriate vasculatures, and then circulated by cardiac dynamic agency through an all-pervading systemic series of elaborately organised channels to every part of that organism, there to be made available for the nutrition of all its parts. It is a fluid, therefore, of a most composite character, inasmuch as it thus consists of materials representing every phase of physiologico-chemical, or chemico-physiological, union, admixture, and condition, and every stage of chemico-dynamic activity and molecular potentiality, so to speak—from the physiologically integrative and organic to the *pathologically* disintegrative or inorganic—the extremes of dynamicism

and adynamicism characterising the behaviour of the sanguineous molecule in its relations to the operation of the laws of metabolism and the maintenance of vital cohesion and structural continuity or life.

The blood may fairly and truly be regarded as equally composed of nutritive plasma and post-nutritive or dis-integrated material, both being, or having been, emptied into the common stream, the former to meet the wants of worn-out or wasted tissue, the latter to be still made subservient, so far as it can be, to the wants of the organism, or excreted as no longer utilisable, or, it may be, hurtful. The processes of digestion and assimilation may be said to have energised or vitalised the former, while the process of vital exercise, organic tear and wear, has de-energised or de-vitalised the latter.

The process of vitalisation of the blood plasma is accomplished in the long series of changes through which it passes in its reduction from the raw food elements to its integration by the tissue elements, and consists, or results, in the conversion of much of it into homogeneous *liquor sanguinis* and granules, corpuscles, lymphocytes, and whatever else of organised character is assumed by, or detectable in, its circulating materials. This description, of course, only applies to its proper alimentary part, the other, or proper lymphatic part, being mingled with it after its collection from the lymph spaces and its subjection to a kindred process of glandular or organic assortment, so far as its devitalised materials can lend themselves to such a process; lymphocytosis even here being possible by the hæmogenetic function of the bone marrow and lymphatic glands proper. The blood so constituted can, consequently, not be physiologically divided into its respective elements of, or distinguished as, new alimentary materials and old proper lymphatic elements, except by colour. We must, therefore, at all times remember that in the human blood we have clinically to deal with a fluid everywhere containing and circulating much devitalised and adynamic material, as well as the future nutritive pabulum of the tissues, vitalised and dynamic with the energy of life, and capable of assuming every form of organisation to be met with

in the body. So long, therefore, as the physiological balance between the two elements characterises the composition of the blood and its distribution, so long will the health of the body be maintained; but so soon as that balance is disturbed, in like manner will it be followed by a proportionate pathological departure from that condition.

Besides the functions above, merely hinted at or implied, we must be prepared to find that there exists in the *blood machinery*, apart from, but intrinsically resident in it, a most elaborate system of chemical attraction and repulsion, and a power of *physiological assortment* by which the fresh or nutritive plasmic elements are separated, or rather kept separate, from the used-up or non-nutritive, and the processes of metabolism and integration of tissue secured and maintained, while simultaneously the hygiene of the whole vital area is accomplished by appropriate systemic effluents, or excretionary agencies, the main examples of which may be adduced as the intestinal, the renal, the pulmonary, and the cutaneous.

The performance of such many-sided chemico-physiological work, as thus outlined, not only implies, but necessitates, the existence, within the apparently simple and elemental blood fluid, of a most elaborate organic and organising machinery, as we have said; and this we are warranted in seeing in, and assigning to, its corpuscular elements, from their ubiquitous existence, their high structural character, their power of lending themselves to circulatory disposal, and their absolutely living condition, with their dynamically active ability to dispose or distribute, and chemico-physiologically assort, the blood plasma into the elemental constituents of the various structural elements of the body, while at the same time engaging in the vital work of removal of effete and used-up or katabolic materials.

Thus a vital chemistry is at work here which must baffle the most skilful experimentation to imitate, and which oversteps the tiny environments of science as yet known and practically applied, and reduces to one composite whole the ever active vital physics and dynamics of organism to the end that life may be begun, continued,

and perpetuated, or, in a word, evolved from forces and materials devoid of life. In this process we, therefore, are compelled to observe that vital chemistry knows little, and utilises less, of the strict "letter of the law," in its methods of dealing with the elements of matter by the vital processes of dynamic charge and discharge, and that it has short and effective means of dealing with the problems of nutrition and tissue metabolism, which nothing but "vital law" can perform; verily, although science, chemical and physiological, has done much to unravel the secrets of life, there comes a limit to its achievements when the proceedings of that great entity are to be surveyed in its everyday work. The *living* current of the blood, as it rushes through our field of vision, or is subjected to the most crucial, but still *non-vital*, tests of *non-living* science, is carrying with it its ten thousand secrets, hidden beyond the microscope's reach, and removed from the possibility of chemical investigation; consequently, the secret of life, we feel justified here in claiming, *is the most sacred in nature*, the very "Lhasa" of science, and the perennial justification of the best and most aspiring efforts which the ingenuity of mankind can put forth, or the intelligence of man carry out.

It would not be too much to say that the chemistry of the *living blood* contains the secret of "the unification of the elements," the working out on vitally dynamic lines of the charge and discharge of its organic molecular energy, the positively charged molecules representing the elements of *living matter* or organising material, and the negatively charged molecules the elements of *dying* or *dead matter* or disorganising material, each with their mutual attractions and repulsions, and their intrinsic powers of life and death. Thus it would seem that nutrition and metabolism, or the processes of integration and disintegration, can be carried out within the same organism by the alternate charge and discharge of its molecular magazines, and the continued existence therein of mutual affinity and repulsion of negative and positive energy within the substance of, and actually composing, its molecules or atoms; *their dynamic condition*, therefore, becomes the key to the *vital position* or *the secret of life*,

with its implied negative death and its emissary disease, and may be said, with a stretch of the scientific imagination, to shed *a ray of light* into the darkness surrounding these great problems, as well as the problem of matter and energy generally. Energy, in all its varieties, radio-activity, and matter ponderable and imponderable, thus shrink into a nearness of relationship and likeness of character, which may be made to yield some day, to well-directed investigation of the biological, physical, and dynamic departments of science, stupendous results, abstract and applied.

Instead of being separated by great gulfs, all these departments of science together constitute but an unbroken line of ascent, from the simple to the complex, from the elementary to the organised, from the material to the dynamic, from the dead to the living; in short, from matter to spirit, in which the negative, or temporary, at last gives place to or merges in the positive, the affirmative, or the eternal—matter, energy, and spirit thus constituting the universe, when the “fulness of the time” at last arrives, and forming an unbroken whole of the “entire world,” in which “death at last shall,” in truth, “be swallowed up in victory,” and when science and revelation will *stand for ever joined* in mutual agreement, and oneness of end and aim, the bulwarks of eternal truth.

EXTRACT XLVIII. A.

ON RESPIRATION, PULMONARY AND CEPHALIC.

RESPIRATION is, or may be regarded as, a process of chemico-physiological admixture of atmospheric air with the blood, as it passes in minutely subdivided processional order through the lumina of the pulmonary capillaries, under the guidance of a systemico-sympathetically regulated nervine machinery at a measured rate, according to the existing bodily physiological conditions and necessities. In the immediate process of chemico-physiological admixture of air and blood, in the delicate vesicular substance of the ultimate pulmonary textures, an interchange of chemical elements is effected, the immediate outcome of which is the disengagement or discharge of superabundant carbon and the engagement or substitution of subabundant oxygen, which latter becomes the predominant chemical instrument of metabolic change in the prolonged and complex processes of nutrition and elimination, which make up in great part the chemico-physical phenomena of life. It therefore becomes self-evident that a physiologically perfect performance of this function is essential to the production and maintenance of health, any deviation from which must necessarily be followed by a proportionate alteration of its tone and condition. The chemistry of the process of interchange of gases arising from the contact, or admixture, of the atmospheric air with the blood, in the process of respiration, has not yet been fully mastered; we must, therefore, confine ourselves to treating of only a few of its most salient points, as, for instance, how the two principal physical constituents of

the blood, the corpuscles and *liquor sanguinis*, are respectively affected by the changes ensuing in the process of aëration, and how the economy of systemic innervation is secondarily affected. Aëration of the blood in the lungs is necessarily a continuous or rhythmical process, which keeps pace with the pulmonary circulation, as it disseminates throughout the pulmonary capillary vessels, the impure blood returning from the body, re-collects it after *renewal* or oxygenation, and returns it into the heart for redistribution; and is determined and effected by a closely related cardiac-pulmonary nervature, which conjoins the two sets of organs within the same nervine "sphere of influence," and "*operates*" them by the same central nervine management, so to speak, thus securing a oneness of physiological purpose and a combined functional result.

The corpuscular, or what we may call the more organised and vitalised element of the blood, undergoes a visible alteration in colour in its exposure to air, evidently due to chemico-physiological molecular change and exchange, in its organic constituents, of a most essential and far-reaching nature, in virtue of which a noxiously laden metabolic vehicle becomes again the bearer to "every hole and corner" of the body, of physiologically pure tissue pabulum, suitable for the anabolic wants of the wasted, or katabolised, organism, which it distributes with the metabolic power due to corpuscular, or vital, energy and active organic chemical affinity, as the varying needs of the several tissue elements demand.

Each corpuscle of the arterial blood may thus be regarded as conveying matter and energy, derived from atmospheric air and venous blood, to every organic element of the body, on the expenditure of which, in exchange for used-up organic elements, it once more returns to the pulmonary "place of exchange," to leave its used-up burden, and once more to "furnish its coffers" with the required *vital* "currency," for the vital and continuous work of organic exchange.

Each corpuscle, moreover, being possessed of the passive power of independent movement and disposal within the blood stream, may be regarded as communicating with its

neighbouring corpuscles, and thus by itself, or through them directly, or indirectly, with every cell lining the blood vasculature, and thence with every cell directly associated by contiguity of cell body, or continuity of cell process, with that vasculature, hence the influence of the corpuscle may be said to be felt universally throughout the hæmal, and associated structural, or organic, elements of the body.

The *liquor sanguinis*, the other great blood element, may be regarded as conveying everywhere, in somewhat like manner, the perhaps less organised and vitalised constituents of tissue plasma supplying the structures requiring such, and re-collecting by osmosis, perhaps, certain lymphoid elements of tissue waste, for conversion to future use, or for elimination through the various excretory agencies of the body and the lungs, the bowel, or intestinal canal, the kidneys, and the skin.

That the alimentary elements, organic and inorganic, solid, liquid, and gaseous, entering the body, and requiring for their metabolic disposal the services of its entire organic machinery, are, under normal physiological conditions, exactly balanced in weight and chemical equivalents by waste products in the form of the materials transpired, exhaled, exuded, and excreted, or leaving the body, is a statement, the truth of which, on such grounds as the above, must now be accepted as axiomatic. When the physiological estimate of the quantity of ingesta necessary for the maintenance of physiological health has been formed, it behoves that that estimate ought always to be the basis of demand and supply, and that any departure from it ought to be made on true physiological lines. The quality, as well as quantity of the ingesta, however, must also be subject to physiological determination and limitation as well, or a departure from the standard of physiological health must ensue, of a magnitude proportionate to the departure from the physiological rule of choice. In this latter respect the lower animals, and some of our more savage fellow-creatures, maintain a higher standard of choice, in respect of quantity and quality, when free to choose, than does so-called civilised man; and so maintain the continuity of physiological health

to a greater degree than the latter does, even with the assistance of "printed rules."

Referring further to the two great blood constituents—the corpuscular and the *liquor sanguinis*—it may be remarked that the former, at least the red corpuscles, acts from within the blood-stream, in effecting those metabolic processes in the economy of nutrition for which it is responsible, with the exception of what is effected by the "wandering cells" which escape through the interstices of the lining vascular endothelium to perform most important hygienic, and other more or less known physiological work in extra-vascular regions—this, of course, refers to the non-red corpuscles only—the latter, the *liquor sanguinis*, escapes through the vascular endothelium by, we would suppose, cell agency, into the cells and fibres, or cell processes, of the whole so-called extra-vascular structures of the body, and into the stroma of the systemic nervine basis, the neuroglia, when it is utilised by the extra-vascular, or sympathetically innervated structures, and the systemic nerve structures, with their muscular and other continuations respectively.

The red corpuscles thus never leave the blood-stream, continuing to circulate therein while its vasculature remains intact, but disseminate their nutritive materials and chemico-physical energy by cell and fibre continuity to the most distant parts and structural elements of the body; the white corpuscles, however, are allowed a greater latitude of movement, in that they are permitted to penetrate to the regions lying outside the blood vasculature, where their phagocytic and anti-pathogenic powers are utilised in maintaining tissue hygiene, and promoting extra-vascular physiological change and circulation within the compass and reach of their somewhat extended opportunities and vital powers. The *liquor sanguinis*, from its lymphoid character, necessarily may penetrate the walls of the entire blood vasculature, by osmosis, and pass directly through those apertures in it permeable by the white corpuscles, but we must be prepared to find that its nutrient circulatory distribution is confined within such limits as secure its reaching, in its physiologically pure state, the tissues whose wants it is destined to supply in

order that the lymphatic vasculature should have to deal alone with the effete lymph resulting from tissue waste. We are warranted in assuming, therefore, that this is effected by the same cell and fibre distributive and circulative machinery, as that by which the corpuscular metabolic elements are circulated and distributed. The existence of such restricted and safeguarded blood-circulatory provisions obviate the occurrence of admixture of physiologically pure hæmal lymph, with effete and noxious tissue lymph, and secures the performance of the process of nutrition in an unincumbered and aseptic manner.

Furthermore, in the economy of aëration or oxygenation of the blood, we have become convinced that we have a great *supplementary respiratory mechanism* in the system of pneumatic spaces occupying the face and base of the skull, a series of spaces which, besides that of respiratory supplementation, no doubt perform most important mechanical and other offices. These spaces are generally symmetrical in topographical arrangement, and conform to a uniform general plan of anatomical disposition, but, in individual cases, depart considerably in both respects from these conditions; they are lined by a very thin mucous membrane, which, therefore, easily lends itself to the occurrence of osmosis and chemical interchange between the air occupying them and the blood circulating in their walls, by diffusion and consequent synthetic and analytic rearrangement of the elements occupying the respective areas. In such, what we would call conspicuous, seemingly purposive, arrangements, who can fail to recognise that we have here an adaptation of the principle of respiratory function to the local wants of the principal vital organs and structures of the body? and, therefore, that we are warranted in claiming their special local anatomical dispositions and arrangements as *supplementary or cephalic lungs*, and that they must perform functions proportionately important in the great function of blood purification in connection with central nervine function, cerebral and peripheral? Moreover, the closeness of the anatomical relationship between these cephalic lungs and the overlying brain structures, lends support

to the further opinion that circulatory *immediateness and availability* are here the counterparts of each other, and therefore, instead of being accidental and negligible, these contiguous textural and organic arrangements must be regarded as important structural features and parts of a great biological design, the full proportions and beauty of which are still hid from view, although, when seen from certain points, it becomes "dimly visible" and profoundly suggestive.

The physiological results of cephalic blood aëration and oxygenation must thus involve local chemical and physical changes of an importance to the brain, and connected nervous system, comparable in many respects to those effected by pulmonary aëration and oxygenation in the metabolism of the body generally, and, therefore, the integrity of the local anatomical structures and their functional wholeness become essential in relation to the proper performance of man's highest psychological and neural work. The so-called *trivial affections* of these somewhat neglected air-chambers and subsidiary respiratory regions thus become morbid entities of great importance, whose treatment it behoves us to place on a more scientific basis than that on which we have hitherto been content to apply it.

EXTRACT XLVIII. B.

ON RESPIRATION, AND ATMOSPHERIC AIR.

ATMOSPHERIC air is as essential for the maintenance of life as food itself ; indeed, it may be called a food with strict scientific accuracy, inasmuch as it is engaged, in all metabolic processes, in carrying into the intra-structural voids, by means of its oxygen, the elements of tissue protoplasm, and in carrying out the elements of broken-down and effete tissue elements. In this chemico-physiological work it may be said to resemble in its *modus operandi* the physical work performed in the economy of circulation by the physical element water, and like it, it is universally present throughout the areas of the globe, wherever life, in all its higher forms, is functionally active.

Vegetable and animal life take from, and add to, the "sum and substance" of atmospheric air their respective nutritive and refuse gaseous elements, in such manner and quantity as to maintain, by the law of gaseous diffusion, an equable distribution of its dual life-supporting elements, and so, by a principle of reciprocity, the two great kingdoms of nature co-exist, and perform their respective functions, in the great laboratory of nature, in biological harmony.

Could the quantity of air taken into the respiratory organism of a human being, in the course of a definite period, be accurately weighed or measured, it would be found to bear a proportion to the quantity of solid and liquid food consumed, little, if at all, inferior materially, and perhaps of as great dynamic importance, in the economy of metabolism.

Respiration, therefore, becomes a function of equal physiological importance with alimentation, and of even greater immediate imminence in the economy of life, since its rhythmic continuity is essential, every few seconds of time, to meet the demands of the blood streams as they circulate through the capillary elements of the respiratory mucosa—that mucosa embracing the linings of the nasal passages, the pneumatic spaces of the head and face, or the cephalic lungs, the larynx, trachea, bronchi, bronchioles, and pulmonary vesicles.

It must be borne in mind that the whole extent of the submucous capillary blood vasculature of the air-passages partakes in the performance, to a greater or lesser extent, in accordance with the thickness or thinness of the epithelium, in the phenomena of oxygenation or arterialisation of the blood, and that the “cephalic lungs” especially, from the diaphanous condition of their lining membranes, afford very great facilities for respiratory gas exchange and local blood purification, with consequent vital effects on the superimposed cerebral structures.

Each inspiration and expiration balances the other, and constitutes an act of respiration, but how different, in the chemical and physical character of their respective gases and vapours, they are! Inspiration passing in, it should be, the purest of air to the exposed blood, while expiration receives, for elimination, the residual gaseous products of chemico-physiological activity and tissue waste.

The first respiration and the last mark the beginning and end of independent life, and form the terminal extremities of that longer or shorter “breath of life” which constitutes the “span” of human existence. As the vehicular requirements of the process of nutrition are met by the principle of aqueous circulation of material plasma, in mass and in molecule, so are its specific final metabolic phenomena met by the physiologico-chemical activities of atmospheric air, and the structural integrity and life of the tissues maintained in normal physiological condition, material and dynamic, by its oxydising and de-oxydising influences in the processes of tissue integration and disintegration.

Oxygen, being held in mere suspension by the other elements of the atmosphere, is immediately available for the chemical phenomena of metabolism, without the necessity of antecedent chemical disunion, and so can effect, from the moment of its introduction into the blood stream, those changes in its chemico-physiological condition constituting the transmutation of the venous into arterial blood, with all the subsequent changes involved in the subsequent re-conversion of the arterial into venous blood. Whether the other ingredients of atmospheric air subserve any purpose in the effecting of aëration of the blood, and the performance of metabolic function, is yet unproved; but the inference is at least legitimate that they are not altogether devoid of physiological or chemical influence in the complex processes of hæmogenesis and nutrition, as, in all great and small natural processes, no element in their performance is without its effect, negative or positive, and, therefore, we may believe that here we have to do with no exception to the rule; hence, science must still pursue her enquiries into this comparative *terra incognita* of chemico-physiology.

As we have said, the physical element of water, and the chemical element of oxygen, pursue analogous courses in the process of nutrition—the former dissolving or suspending, and the latter chemically combining with, the elements of the nutritive pabulum submitted to the exhausted tissues, each combining with the other in carrying out the complex details of the materio-dynamic process of tissue waste and repair.

Water thus constitutes the circulating medium in which the supply of fresh nutritive materials are conveyed to the worn and wasted tissues, while oxygen constitutes the intrinsic element of chemical currency by which the problems of exchange are effected in the disposal of new for old tissue constituents.

In the cryptic process of metabolism we are yet far from knowing exactly what takes place, and how its details, chemical and physiological, are effected, as well as what constitutes the line of normal procedure or absolutely healthy action, and what may be looked upon as an altogether pathological departure from the standard

of health, dynamic and material, or both. As to this latter aspect of the matter, however, it is impossible to think, although we may have had what we consider ocular demonstration, that the dynamic and material conditions can be altered independently of each other, so we must universally regard them as complementary of each other, and as mutually essential for the making up of any and every vital procedure, be it physiological or chemical, or both, and that, therefore, their simultaneous occurrence is implied in all instances of departure from the normal, as well as abnormal, standard.

Defective or impure air supply presupposes, therefore, the defective performance of metabolism, with material and functional defect in the physiological condition of vitality in all its phases, material and dynamic, in proportion to the extent and continuance of the aërial defect or impurity, and in degree varying from the non-perceptible to the incidence of the most advanced non-oxygenation or hæmal autotoxis. The immediate and remote effects, therefore, of the due performance of respiration "loom largely" as etiological factors in the incidence of a large area of diseased conditions, and as a determining influence in human happiness and individual usefulness in the affairs of the world and the progress of civilisation and human destiny. Thus it behoves the individual and the nation to endeavour to make the supply of atmospheric air as absolutely pure and undefiled as nature originally provides it, so as to secure one great health-giving element in all human and vital concerns generally, and the element, above all natural elements, in the maintenance of the health and happiness of the human race and the whole animal kingdom. Air, pure air, and plenty of it, must, therefore, ever be sought after as a means of preserving the health of the individual and the nation, besides retrieving the disasters of malaëration so frequently observed at the present day throughout the length and the breadth of the land, which are at present calling aloud for aid to both the laity and the profession of medicine.

Air is provided by nature; food, including water and clothing, are the only other human requirements for the

purpose of life, and ought to be universally available. We must, therefore, use every means within our power, both individually and nationally, in order that these should be put within the reach of all who make a *legitimate* effort to acquire them, and who, when these *legitimate* efforts fail in procuring them, may be assisted in obtaining them, so as to leave as small a residuum of absolute idlers as possible to be *dealt with otherwise*.

It has been said on the highest authority that "man does not live by bread alone"; what he does live by, therefore, in addition to those means which he ought to be able to provide, is the "free air" of heaven, and that he ought to have in as pure a condition as it is possible to supply it by all the means within the reach of civilised man to procure it, so that ultimately there may be placed within the reach of every member of the great human family the complete means of maintaining life in comfort, if not in happiness.

Pure air is the enemy of disease, the corner-stone of the foundation of health, and the great upholder of life in all its advanced phases; as ablution and cleanliness are next to godliness, so is, and much more, pure air to the health, bodily and mental, of man. The gospel of the provision of the necessities of life must, therefore, be associated with the gospel of cleanliness, and all that is sweet and of "good report," to the end that all that is peculiarly desirable in the individual and the community may follow as the great *progress of cause and effect* evolves itself in ever-increasing degree of perfection of result, and more and more wide-spreading and all-embracing universality of incidence.

EXTRACT XLIX. A.

ON THE OSSEOUS COVERINGS OF THE CENTRAL NERVOUS SYSTEM.

A SYSTEM of the importance to the vital well-being of the individual organism, such as the systemic nervous system undoubtedly is, would seem to require for its accommodation, support, and protection, a hollow osseous structure, stable enough to afford a material foundation on which it can rest, and yielding enough to permit of a certain measure of movement of its component parts to meet the requirements of the remainder of the osseous skeleton, to which it is articulated in relation to position, locomotion, and prehension. This hollow osseous structure is provided in the skull and spinal column, and is developed, by a process of ossification, from a series of central points laid down in the embryonic matrix surrounding the nascent central nerve elements.

That part of the bony structure of the body here referred to is the earliest to be laid down of the skeletal framework, in and around which the soft structures composing that body can grow, or are developed, with safety and regularity in obedience to the laws of development and evolution. The structure of the bones of the skull is a compound of originally separated cartilaginous or membranous and independent osseous units, but finally of a closely articulated and continuous osseous enclosing envelope, and consists of an outer and inner more or less solid framework, with a central spongy or porous *diploë*; this latter, in the case of the skull bones, terminating in,

or blending with, the air spaces of the base of the skull and upper bones of the face.

In this latter anatomical arrangement, we think, is provided a means of external drainage of the intra-cranial lymph spaces through the patent mechanism afforded by the Pacchionian bodies on their traversing the inner table of the skull and cancellous texture of the overlying *diploë*, and it may be to some extent the outer table and pericranium, hence the growth of "wens," etc.

Thus, this osseous encasement affords both protection and support of the most substantial character to the central nervous system, while at the same time it provides facilities for a supplementary lymph drainage system by which the exigencies of intra-cranial pressure can be met, and, it may be, neutralised, on the principle of "give and take," or "tidal fluctuation," so to speak.

EXTRACT XLIX. B.

ON THE MENINGEAL COVERINGS OF THE BRAIN AND SPINAL CORD.

THE meninges of the brain and spinal cord, with the neurilemmar coverings of the nerves, being so intimately connected with the nerve structures proper, and with the economy of their lymph circulation, call for a word of description, in order to provide for a more complete continuity of view of the broken subjects, although, we hope, somewhat connected narrative of our studies. The most external of these meningeal coverings, the *dura mater*, so named from its dense and unyielding texture, lines the cranial cavity, to the bones of which it is most intimately united by a thick-set series of fibrous projections, and constitutes the internal periosteum of the skull; at different points of the ridges and surfaces, of which it splits up to form the venous channels or sinuses, and projects itself under and between the various divisions and hemispheres of the cerebrum and cerebellum, the proper anatomical position and relationships of which it largely assists in maintaining—after which it leaves the cranial cavity by way of the *foramen magnum*, where its external layer becomes continuous with the pericranium, while its internal layers are continued along the spinal canal to its extremity, whence it is emitted as the substance and enclosing layer of the structure known as the *filum terminale*, until, as we think, its junction with the glandular body denominated coccygeal. Throughout all this extent its texture is histologically continuous, being one and indivisible, save for the numerous openings, or

foramina, provided in it for the passage of nerves and blood-vessels—which openings, however, are not to be recognised as openings in the strict sense of the word, but as peripheral or lateral continuations of the dural membrane. Thus, it is obvious we have to deal here with a meningeal texture, continuous from its inception, as the lining and covering respectively of the cerebral and spinal cavities and their contained structures, to its termination in the neurilemmar sheaths and spaces, where the nerve terminals or arborisations constitute its external or peripheral boundary. It goes without saying, therefore, that the spaces enclosed by it must be equally continuous, and that the fluid contents which circulate therein or therethrough, must in turn conform in their movements or circulation to their solid environments.

The second meningeal texture, the arachnoid, the individuality of which is explained away by some authorities, follows the anatomical disposition and distribution of the first or *dura mater* with undeviating regularity, and is underlaid by a space of like regularity and continuity, the fluid contents of which are possessed of the same or even greater facilities of circulation than are those of the sub-dural space. These two meninges are sparingly vascular, their functional rôle being mainly mechanical, or supporting and protecting, hence fibrous tissue constitutes the main portion of their substance, their inter-spaces being lined or overlaid by endothelial or epithelial cell investments.

The third meningeal texture, the *pia mater*, is entirely different from the two just described, in histological character being highly vascular and supported by abundance of fibrous tissue, it intimately connects itself with the surrounding arachnoid—as the arachnoid connects itself with the overlying *dura mater*—and with the fibrous meshes of the underlying neuroglial matrix of brain and cord. It is anatomically continuous, therefore, as a covering or envelope, with the peripheral layer or cortex of the brain and cord, as well as with the endoneurium of the nerves and textures carrying the vascular supplies, by which the neuroglial matrix is maintained and the pabulum of the nervous system proper is supplied.

Besides, however, supplying nourishment for the nerve structures, it is instrumental in excreting, or exuding, into the cavities surrounding the central nervous system in all their wide extent, as well as by its attached choroid plexuses into the cavities inter-penetrating the brain and cord, a fluid which has received the name of the cerebro-spinal fluid, and a fluid the functional rôle of which is of the greatest value in safeguarding the delicate textures composing the central as well as the peripheral nervous system, and of aiding and permitting the uninterrupted performance of the complex functions, mechanical as well as physiological.

We would remark that the functional rôle of these meningeal coverings or membranes is also of the highest order, that they perform the important offices within the head and spinal canal of the protection, support, and the affording of facilities for the conveyance of material for nutrition, as well as facilities for the removal of effete matter for excretion from the vitally important organs within their cavities, while they accompany in unbroken continuity every nerve which leaves them. They moreover, between their folds and within their inter-spaces, afford room for the collection of pools, columns, or layers of cerebro-spinal fluid, which become the buffers and liquid supports of the most delicate and impressionable organisms contained within the human body.

The outer or *dura mater* is most adherent on its attached, or outer, surface, hard and strong throughout its substance, and covered with a silkily smooth and glistening surface on its inner, like a wall of cartilage. The arachnoid membrane belies not its name; a peculiarity attaches to it, however, which to us seems to betoken that it may take part in the work of excretion from within the head and which is this—along the immediate neighbourhood of the longitudinal sinus on either side on the roof of the skull, as well as on other parts, a series of small organisms called “Pacchionian bodies” are observed, consisting of duplications or projections of the arachnoid membrane, which penetrate the overlying *dura mater* and bone, at least its vitreous table reaching the *diploë*, or even beyond. These bodies seem almost glandular, and

act as so many percolators, through which an over-compressed cerebro-spinal fluid can find its way out of the cranial cavity into the porous substance of the superimposed bones. In the closely clinging *pia mater* the blood-vessels are conveyed which nourish and sustain the cerebral and spinal nervous structures. Thus is provided a series of structures of most beautiful texture, and most elaborate design and detail, to ensure the safety and nutrition of the most wonderful living mechanism known to science.

EXTRACT XLIX. c.

ON THE CIRCULATION OF THE BLOOD WITHIN THE HEAD.

THE circulation of the blood, apart from the circulation of the lymph, within the skull, is a subject on which a great deal might be said, but it may suffice merely to draw attention to it by a few references. To begin with the arterial, it may be remarked that, when once inside the skull, the great arterial trunks break up freely, anastomose largely, and altogether distribute themselves so as to secure the most complete and guarded supply of blood to every part and section of the cerebral textures, the two sides uniting and commingling their supplies, so as to take advantage to the full of the principle of anastomosis, and to secure an equal distribution of the vital fluid. The basilar vessels are secured from mechanical pressure and impediment to circulation by the presence, throughout every space and inter-space not occupied by proper nervine or meningeal structure, of the ubiquitous cerebro-spinal fluid, and superficially on the walls and crown, by the hollowing of the inner plate of the cranial bones for each artery, so that, when everything is normal, not even arterial pulsation is felt by the sensorium, and the vessels are at liberty to expand and contract without interfering with the freedom of cerebral material movement or function. This is explained and secured by the existence, throughout the whole arterial vasculature of the brain, of a peri-vascular spaceage, identical with it in distribution, in which circulates the cerebro-spinal fluid, accommodating itself to every pulsation and to every

movement of the vaso-motor economy of the vessels, so that, whenever expansion of their lumina takes place, that fluid runs out of, and when contraction ensues, it runs into, that spaceage, whenever and wherever determined by local movement, thus maintaining a condition of equal pressure on the blood vasculature on the one hand, and on the proper cerebral textures on the other. Hence the arteries are said to enter the brain proper "naked" or uncovered by their usual adventitial textures; moreover, they are unaccompanied by veins, and pursue their lonely course through the brain matrix, terminating as usual in the capillaries, which lend themselves to the transfusion of their contents into the neighbouring neuroglial substance, and *do not turn on themselves*, but continue their course until they join the venules, which latter, in turn, converge to form the great venous receptacles called sinuses. The sinuses are not veins, in the structural sense of the term, but irregularly shaped hollows, constituted by splittings and foldings of the meninges at their attached margins, and in some of their free expansions. They, therefore, are not contractile, but are protected from mechanical pressure from the brain structures to which they are related locally, by being placed where these brain structures are discontinuous, as they are wherever the meninges are specially attached to the calvarium; a truly remarkable provision for taking advantage of the splitting up of the meningeal layers of structure, and at the same time placing the sinus cavities in a position as absolutely free from pressure and circulatory impediment as can be secured within the skull. It may therefore be said, with all truth, that the most important organ of the body is lodged in an ideally protected and constructed skeletal cavity, supplied with "observatory" adjuncts of the most marvellously perfect character, and has its food supply secured and supervised by the most perfectly working means which it is possible for the human intelligence to appreciate—all which testify to the great responsibility which rests on the central nervous system to make the best and the utmost use of the situation. It may be conceded, however, in relation to a great part of the lesser, and even more,

intense forms of human suffering, ailments which have not a name beyond that of the general one of "headache," that the condition of the cerebral circulation is largely responsible for them, together with interference with the local and general circulation and excretion of the cerebro-spinal fluid, and the condition of the blood itself with regard to chemical and physiological purity; and, of course, this is not meant to refer to those forms of headache symptomatic of definite diseased conditions or morbid entities.

The popular condition known as "headache" may, therefore, from this point of view, have a light thrown upon it which should be of use in indicating the line of conduct and the treatment, if any, which is most likely to afford that relief, so much longed for, to its subjects who usually suffer long and frequently from it. Its causes being thus very often merely mechanical and chemical, the simplest means may often suffice to afford relief, and when once these have been discovered and adopted, recourse to them becomes habitual, and by and bye the condition ceases to recur.

Of course, for conditions involving the textural condition of the intra-cranial contents, each condition requires to be considered and dealt with on its own merits.

EXTRACT L. A.

ON THE "PNEUMATIC SPACES" OF THE HEAD AND FACE, AND THE OLFACTORY NERVES AND MUCOSA.

THE anatomy and physiology of the pneumatic spaces, so called, and the olfactory apparatus lie at the foundation of this series of studies.

It appears to us that the pneumatic spaces, so called, of the head and face fulfil: *first*, a mechanical purpose by lightening the osseous structures of the facial and cephalic skeleton; *second*, they render more yielding the floor of the skull and points of entrance and exit of the cephalic nerves and blood-vessels; *third*, they give facilities for the conduction and modulation of sound; and *fourth*, they minimise the effects of shock or concussion on the cephalic contents by affording, so to speak, an air-cushioned chamber for their safe lodgment. In this connection they may also be said to afford a means of modifying and mellowing the quality and tone of the voice—making it more or less cavernous, sonorous, or in reality *antral*.

Amongst the physiological functions subserved by them may be enumerated the following, viz. a surface for the chemical interchange, or exit and entrance, of gases or liquids, which may leave it or become vapourised and join the air currents in the nasal-pharyngeal cavities, thus providing a subsidiary breathing apparatus, as it were, for the head, face, and neck; so that, when the contents of the cephalic cavity cannot be sufficiently aerated and purified through the ordinary channels of exit and entrance, a safety valve is thus provided, or opened, and a supplemental oxygenating agency supplied to

prevent disaster, while a see-saw, or compensatory agency, may thus be established between the cutaneous surface of the face and head and the lining membrane of these cavities, whereby pressure on the encephalon is obviated under circumstances in which that pressure might be liable to disturbance; thus a simple “pallor of the cheeks” may be followed and counterbalanced by a “delicate blush,” the “marble blanch of profound shock” by a “scarlet suffusion,” compensation being effected by the alternate opening and closing, or *vice versa*, of the appropriate external and internal blood channels—*external* and *internal sweating, alternately cutaneously and naso-pharyngeally*, may in like manner, and for like purposes, occur. We have in such provisions, therefore, supplemental intra-cranial pressure safeguards and protections in these environments of the cranial contents.

It may also be here stated, that the sounds produced and the minute shocks conveyed by the process of mastication, as well as the noise created by the acts of deglutition and phonation, seem to be softened down, and made more bearable for the organs of sense and the brain above.

The anatomical and histological aspects of the subject of the olfactory nerves and their use as an excretory mechanism, having elsewhere been pretty fully dealt with, we have, therefore, on this matter, only a few observations to make in supplement. It is said that the olfactory trunks, which are hollow in many animals throughout life, and in the human species up till adult age has been nearly reached, become *closed*, as life advances beyond that period. This may be so, but we apprehend that *closure*, so called, is only *clogging*, and hence a matter of degree ranging between partial patency and complete occlusion.

This view may be sufficient to account for the frequent, we might almost say the copious, and regular nasal discharge in the young, and the comparative absence of it, at least the more fluid part of the discharge, in the grown-up and aged.

Thus, we perceive that the very active period of life, when the nervous system is most plastic, and when

muscular movement is most constant and violent, an outlet is provided by which waste products are allowed to *run off* most directly and easily, in order to the saving of the more distant emunctories, or outlets, such as the sweat glands and the coccygeal excretory apparatus.

We thus see—it may be somewhat imperfectly—that the comparative freedom of childhood and youth from the incidence of such diseases as rheumatism, in all its varieties, may be due to the patency of the olfactory excretory organism, and that advancing age accounts for the prevalence of such diseases by the gradual clogging up of that organism, and the consequent delegation of this part of the excretory functions of the nervous system to the pituitary outfall, the cutaneous and other surfaces, as well as to the before-mentioned coccygeal glomerulus and associated parts.

All this seems the more probable because, as the power to take physical exercise decreases with advancing age, the effete products of neuroglial disintegration and nervine “tear and wear” accumulate in the cerebro-spinal lymph of the body, and not finding an exit by the skin, which has to a great extent ceased to carry on its active functions of excretion or diaphoresis, begin to act as pathological presences, both within and without the proper nerve structures, interfering with their vital processes, and acting as mechanical impedimenta.

In connection with olfactory excretion some mention ought perhaps to be made of snuff-taking.

Snuff-taking, in its physiological bearings, may to some extent be understood, when considered in connection with the application of these views.

Thus snuff, which is a narcotic irritant, when brought in contact with the Schneiderian membrane, induces in the unaccustomed indulger of the habit more or fewer violent acts of sneezing, with copious nasal discharges, and in the seasoned devotee the concluding stage of the above process, and the gratification of a much enjoyed habit, with the result that the olfactory and surrounding structures are relieved, and this relief is followed by a greater or lesser relief to the tension of the cerebro-spinal cavity that may exist.

Hence the snuffer, or snuff-taker, when he wants to cogitate deeply, helps himself to his much-loved *pinch*.

In further connection with the subject of snuff-taking, as conducing to the unloading of the cerebro-spinal cavity of its surplus fluid contents, and thus aiding in the work of the senses and intellect, it might be asked if it might not thus indirectly aid in the excretion of such morbid products as the *materies morbi* of rheumatism, and whether, therefore, snuffers are less afflicted with that and kindred diseases than are non-snuffers?

Snuffers may be said to induce artificial sweating from the olfactory mucous membrane.

As bearing on the anatomy and distribution of the olfactory nerve fibres in and on the dog's nose, and a large number of the lower animals of that and other species, it would be most interesting, and it might be useful to know, whether the membrane or skin reflected over the point of the nose contained terminal fibrils of the olfactory nerve, and, consequently, the sense of smell, or whether its range of sensory power is purely tactile.

We might almost be warranted, however, in inferring from what we observe in the dog, and a very large number of the mammalia, that the structure in question *is* permeated by terminal fibres of the olfactory nerve, or other nerve elements capable of appreciating certain qualities of matter, odoriferous or otherwise, whereby they are enabled to select their food with greater ease and exactitude, and even to perceive with less effort distant objects, provided these objects are shedding odorous particles.

This covering, or nasal cap, seems to be a mucous, or modified mucous, membrane, continuous with that of the nasal passages, and being generally moist, it may be, from that continuity, it presents a surface to which floating particles of matter readily adhere, and from which nervous molecular impressions are conveyed to the sensorium.

This surface, therefore, becomes a part, and may be called the “advanced guard,” of the proper sense of smell in its relationship to environment.

A somewhat similar office appears to be served by the lips in connection with the sense of taste.

EXTRACT L. B.

ON THE LACHRYMAL GLANDS.

THE lachrymal glands seem to us to resemble the coccygeal gland in anatomical texture, and, like it, to constitute a part of the great "system" of excretory organs for emptying or running off, by their functional exercise, the superabundant fluid contents of the cerebro-spinal lymph spaces. At least this constitutes part of the function of these glands, and is operative when the necessity arises, as in overdistention of these lymph spaces, or on occasion of glandular activity, such as may arise in weeping; another part of their glandular function being, when fluid cannot be drawn from cerebro-spinal sources, the extraction by the proper gland structures of the appropriate materials from their blood supply or contents which can be resorted to, to meet any temporary necessity. Thus, the constant necessity of maintaining an uninterrupted supply of appropriate fluid for lubricating and other purposes is met and ensured by these double sources of supply, the neural and hæmal, in the important structures constituting and surrounding the orbital and auditory, and, by similar means, the anal orifices of the body. In textural arrangements and anatomical characteristics these glands, the lachrymal and coccygeal, closely resemble each other, the great difference being that the lachrymal are symmetrically disposed on the *two* sides of the body to meet the requirements of its two sides, while the coccygeal gland is centrally situated to afford an outlet to the *single* posterior termination of the spinal cord, the *filum terminale*. The anterior and double and the posterior and single glandular structures here men-

tioned are, therefore, determined, both as to situation and number, by the anatomical necessities of their positions and functions in relation to the central cerebro-spinal nervous system.

EXTRACT LI. A.

ON THE ROOF AND FLOOR OF THE MOUTH, AND THE TONGUE.

THE roof of the mouth is a partly irregularly ridged and partly smooth mucous membrane covered surface, against which the upper surface of the tongue is more or less constantly laid, and between whose surfaces there is more or less constant friction, and consequent epithelial denudation.

In the apposition of the surfaces a greater or lesser degree of discomfort is experienced, unless a certain amount of moisture is included in the inter-space. This moisture may be obtained to a certain extent from the surfaces themselves, or from the saliva flowing from the ducts of the various glands opening into the cavity of the mouth at various levels.

In the situation of the parts, as thus viewed, it will be observed that the salivary ducts open into the mouth at a lower level than that of the upper surface of the tongue when opposed to the palatal roof; hence a difficulty is experienced in keeping the appropriate amount of moisture supplied when that organ is at rest in that position.

This apparent difficulty would be met, or would not arise, were a sufficient supply always forthcoming from either of the surfaces mentioned, and could it be available in that condition—the condition of rest—or, for that part of it, in any or all of their conditions.

As meeting this want, and affording this supply, we are of opinion that we see it, and sometimes feel it, at the slight eminence situated at the exit of the anterior

palatine canal, behind the upper incisor teeth, where, to our mind, the nasal floors, with the organs of Jacobson, empty themselves by capillary openings in the extremities of the ducts penetrating the canal. The organs of Jacobson empty themselves into the inferior nasal passages just, or almost, over the entrance to the ducts known as leading through the anterior palatine canal, and may, at an early period of life especially, or when these ducts are said to be patent, find a ready channel, or channels, through which to gravitate, or be sucked, through capillary tubes into the cavity of the mouth, exactly at the spot required to meet the difficulty in question.

Terminating by somewhat capillary exits, the process of evacuation of the ducts, or the flow of the fluid from the nose through them, may be constant or interrupted, according to the position, degree of dryness of the surfaces, and whether they are opposed or unopposed, as well as the changing necessities of the parts, arising from whether they are at rest or in action ; it is accomplished, or attained, by the *sucker-like* action of the lingual surface on or against the roof of the mouth when the intervening air is expressed, as it is when the two surfaces, lingual and palatal, are intimately opposed to, and then withdrawn from, each other, as is to be observed during infant sucking, and many of the movements, infantine and adult, peculiar to the lingual organ in its to and fro apposition with the roof of the mouth. Who has not noticed the great advantage and comfort of a preliminary and timely moistening of the two surfaces in question when the tongue has to be used for almost any purpose—alimentary or linguistic, or even for passively “chewing the cud of reflection.”

In the economy of mastication and preparation of the food for deglutition the roof of the mouth may be likened to an inverted “nether millstone,” against which, when the food is being ground down by the teeth and insalivated by the various glands, the tongue is constantly engaged triturating and reducing it to a pulp capable of being swallowed and passed into the stomach in a condition suitable for gastric digestion. The rigid surface of the hard palate thus becomes a valuable asset in the economy

of mastication and insalivation, lending itself to the breaking up of the solid, and the disintegration of the insalivated, food, thus affording a basis of passive resistance,

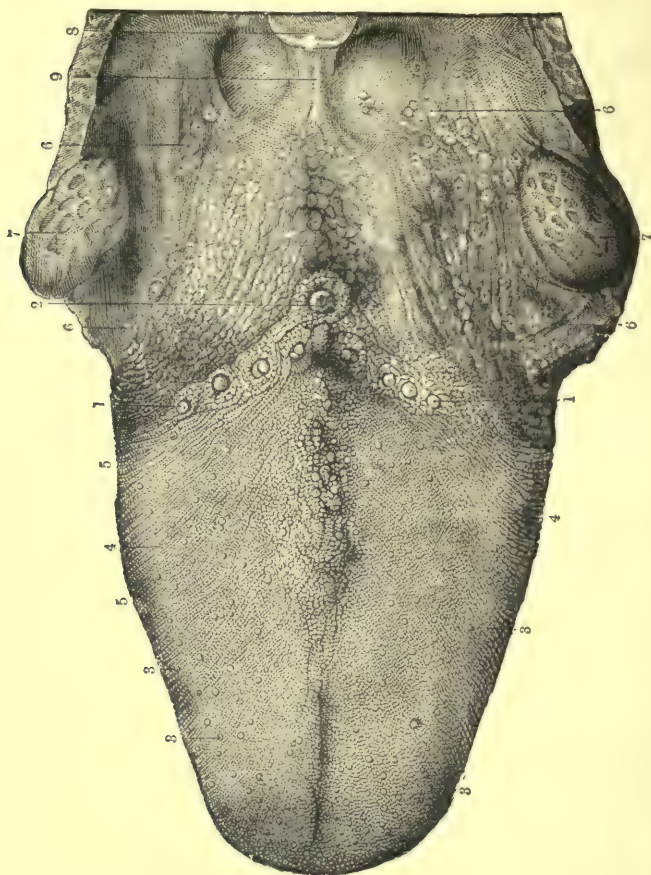


FIG. 132.—PAPILLARY SURFACE OF THE TONGUE, WITH THE FAUCES AND TONSILS. (From Sappey.)

1, 2, circumvallate papillæ; in front of 2, the foramen cæcum; 3, fungiform papillæ; 4, filiform and conical papillæ; 5, transverse and oblique ranges; 6, mucous glands at the base of the tongue and in the fauces; 7, tonsils; 8, part of the epiglottis; 9, median glosso-epiglottic fold or frænum epiglottidis.

against which the tongue, by its serpentine muscular powers, can successfully operate, making the intervening alimentary pulp yield and attenuate until the required degree of plasticity has been reached for it to be passed

on to the pharyngeal musculature for easy deglutition. The floor of the mouth is constituted of the sublingual surfaces and encircling teeth and gums, but more especially of the tongue itself (Fig. 132), which, in a sense, may be looked upon as one of the most remarkable and interesting organs of the body, whether we regard it from a purely anatomical point of view or from that of the services it performs in the economy of life and human relationships. The teeth, the gums, the salivary glands, and the lateral or buccal walls of the cavity of the mouth, each and all perform most important functions in the economy of alimentation, and in the work of enabling the central organ of the mouth, the tongue, to perform its manifold work with the maximum of facility and the minimum of difficulty.

Besides the merely mechanical functions it performs in this combined work, and the many important individual purposes it subserves, we have become possessed, from long observation and what study we could give the subject, of the fixed ideas that a great central and individual function of the tongue is the admixture of that colloidal material represented by its *fur* with the component parts of the food during the linguo-palatal trituration, and that admixture of its *fur* with the food represents a specific digestive function of a vitally important and absolutely necessary character, inasmuch as it is initial, and of large proportion, in the long chain of chemico-physiological phenomena constituting digestion, and what follows.

We have already elsewhere endeavoured to trace the passage of pituitary debris from within the pituitary outfall structures along the tonsillar bodies into the tongue, and we have recognised in the capillary eminences of the lingual mucosa the orifices of lingual excretory ducts, necessitated by the existence in the tongue of this residual cerebral debris or pituitary excretion, removed hither for purposes of cerebral hygiene and neural or neuro-systemic freedom, so to speak. Besides these immediately important functions, basing our deductions on analogies supplied within the alimentary canal throughout its whole extent, and on the great axiomatic principle that

everything capable of further use within the domain of the organic work of the body continues to be utilised to its fullest extent ere it be allowed finally to escape as altogether effete and noxious, we venture to assert that the tongue, like the gastric glandulature, the liver, the pancreas, and intestinal glandulature, discharges into the passing food elements *a great digestive ferment*, whose function is to *reduce* chemico-physiologically certain of these elements

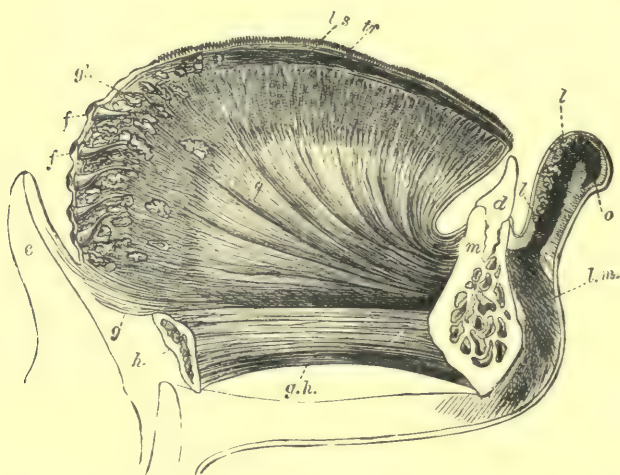


FIG. 133.—LONGITUDINAL VERTICAL SECTION OF THE TONGUE, LIP, ETC.
(From Kölliker and Arnold.)

m, symphysis of the lower jaw; *d*, incisor tooth; *h*, hyoid bone; *g h*, genio-hyoid muscle; *e*, genio-hyo-glossus spreading along the whole of the tongue; *tr*, transverse muscle; *ls*, superior longitudinal muscle; *g l*, lingual glands; *f*, lymphoid crypts; *e*, epiglottis; *l*, section of the lip and labial glands; *o*, cut fibres of the orbicularis oris; *lm*, levator menti.

in preparation for the subsequent stages of digestion. What that function is is as yet hidden, and, therefore, waiting decipherment, after which it cannot be doubted that an instrument of utility will have been gained by the clinician and dietetist of very great intrinsic value and scientific importance and adaptability.

Viewed thus as a glandular receptacle, we may liken the posterior two-thirds of the tongue to a sponge, into which the residual pituitary discharge permeates from the adjoining tonsillar bodies, one of whose functions is to disseminate from their own external surfaces, in like

manner with the tongue, a quantity of this pituitary material, which no doubt becomes utilised for like digestive purposes. The spongy texture of the tongue into which the residual pituitary or tonsillar excretory material percolates, is possessed of a fan-like musculature (Fig. 133), arising and radiating from its ossicles and posterior inferior aspect, and inserting itself into the fibrous sub-mucosal structures, which, on contracting, lessens the universal area of the organ, with the result that its fluid and plastic contents are emptied into the cavity of the mouth through its papillary ducts, as the contents of a sponge can be squeezed out by pressure. It, therefore, follows that the act of mastication, which entails a continued contraction and relaxation of the tongue's musculature, must be attended by a fresh act of pituitary excretion on every such exercise, and that synchronously are, therefore, conducted the processes of dental trituration, insalivation, and *lingual fur admixture* of the food. All which processes must be regarded as absolutely essential in this, the very first stage of digestion and alimentation, for the preparation of the raw materials of that food for the effective action of the succeeding digestive processes and agencies to which they must be subjected, in order to become available for the supply of the nutritive wants of the body.

The tongue, so regarded, must consequently be classed as a *glandular organ*, or rather as the final glandular development in a series of glandular structures known as the pituitary gland, the tonsils, and the tongue, whose chief offices, in this relationship, consist in excreting from the central cerebral organisms the results of neural tissue waste, and in securing the utilisation of these in the process of digestion in the manner, and with the intent, of the other digestive materials poured into the alimentary canal, at its various stages, by the other glandular developments subservient to that process.

EXTRACT LI. B.

ON THE TONGUE, AND WHAT IT INDICATES TO THE CLINICIAN.

“PUT out your tongue, please,” is a request familiar to the ears of the frequenters of clinical establishments, and at the bedsides of the seekers of relief and cure ; and why ? Because information is sought, by the addresser of the request, which can only be elicited from this source, and can only be read in the light of inherited and acquired knowledge, by the descendants of Æsculapius and Hippocrates.

Viewed as a clinical *tell-tale* organ alone, the professors of the healing art are much indebted to it for the passive information which it is able to afford, apart from that which they seek from it in other directions ; it behoves these professors, therefore, not to be satisfied with mere “habit and repute” routine and empirical methods of eliciting the information which they require, and which can be obtained from this source alone, but to enquire more deeply, more exhaustively, and rationally into the structural foundations and functional conditions in which these *sources of information* “take their origin,” and from which the abnormal morbid characters and signs observable on this organ are evolved.

The tongue, when thus considered, is found to have an individual as well as a collective character, which must always be recognised and allowed to have its weight when the important procedure of diagnosis is in progress, and which on all hands is found, more or less, to illumine that most important proceeding, as well as to indicate the lines of treatment and future trend of morbid progress, besides

the rate of convalescence and the complete degree of recovery of health attained. In reading and estimating the characters imprinted on the tongue by nature and disease respectively, we must include those of size, consistency, colour, general appearance and arrangement of papillary textures, local and general, presence or absence of moisture, and local and general development of "fur," and many other less prominent features of health and disease. For our present purpose, however, it will be sufficient if we deal with the last named, or "fur," as being most intimately and generally connected with the presence and effects of morbid processes or disease.

The development of "fur" is not confined to the conditions of disease, but may be found naturally present in many people in the possession of excellent health; we must, therefore, regard its presence or absence as a matter of less than vital importance, but yet a lingual feature of the greatest diagnostic importance in those cases wherein its presence is unmistakably a symptom.

What, then, does "fur," or "furred tongue," signify in the conditions of health and disease respectively?

"Fur" in the healthy is usually a local white or yellowish super-epithelial deposit or exudation—more especially the latter—occupying the back and central two-thirds or so of the tongue's upper surface, and generally thicker in the centre and thinning towards the edges. As we have remarked, it is mostly to be regarded as an exudation. An exudation from where? and an exudation of what? you will ask. As an exudation, of course, it can only come from the epithelial covering of the tongue, with its multitudinous array of papillary cups, and communicating or attached endothelium-lined ducts of sub-communication. The part of the tongue furred is that on which these papillary epithelial arrangements are most in evidence, and we may, therefore, assume that the process of exudation is more active here than elsewhere, and hence may regard the prevailing natural local "fur" production as being due to increased local accumulation of exudate, with proportionately increased difficulty of its disintegration and detachment.

The exudate may be looked upon as mucous or mucoid

in composition, and of use in the many and various activities in which the tongue takes a part. The production of the large amount of this exudate or excretory material, which in the natural and healthy condition of the tongue is constantly being formed and thrown off, requires for its accomplishment not only an elaborate and extensive machinery, but the readily available provision of a large amount of raw and convertible or immediately available material. In the tongue, therefore, we find, and more especially within the meshwork of its muscular structure, in its posterior and middle parts, a large amount of ill-defined and amorphous pseudo- or semi-fatty deposit, which could lend itself to the production of just such material as is exuded by the epithelial membrane of the upper surface of the tongue at its normally or naturally "furred part." This assumption, we think, will supply the answer to your second question, viz. *the exudation of what?* The presence, in the greater part of the body of the tongue, of a large amount of ill-defined or metamorphic material would seem to indicate that that material is there for the purpose of meeting a vital or nutritional local need, or of supplying a "dumping ground" for the future disposal of a used-up and semi-effete material, or both; the former of these indications we may regard as negatived by virtue of the completeness of the vascular mechanism of the organ and its perpetual activity in the most vital processes and everyday work of life; we must, therefore, fall back upon the second indication, that the tongue supplies a "dumping ground" for the future disposal of used-up and semi-effete material; and in answer to the question—*the exudation of what?* we would claim that this ill-defined and amorphous inter-penetrating matricial element of tongue issue forms the raw material of the exudate composing the substance of what is known as tongue "fur."

Another link farther in our interrogations and enquiries will complete the chain we have been endeavouring to forge, and will, we think, enable us to unite into a harmonious system of exudation, or excretion, and circulatory disposal of katabolic cerebral material, a series of circulatory acts or operations as complete and united in their working as is to be found within the human system.

That concluding link is supplied by the anatomical and histological union of the spongy excreting bodies known as the tonsils, whose function we have elsewhere described as cerebro-excretory, with the matrix of the tongue and its abounding, amorphous, indefinite, semi-effete elements, and the more or less wide and otherwise unoccupied inter-fibro-muscular spaces. Here, then, we claim to see the theatre of one of the concluding acts of the great cerebro-excretory circulation and the final disposal of the residual pituitary material, which finds its way into the pituitary gland, and which in turn finds its way through the lateral sphenoidal foraminal openings into the tonsillar bodies, and thence into the amorphous and semi-adipose material matrix, in the inter-muscular spaces of the tongue, where it affords that semi-plastic and faintly fluid material in the discharge of which the epithelial covering and papillary structures of that organ are constantly engaged. Should the truth of these contentions be established, and their physiological importance in the economy of health become a matter of orthodox belief, then it will follow that any pathological departure from the normal structural or functional conditions of the parts involved may become a matter of supreme pathological moment and a morbid entity of the greatest consequence—the recognition, therefore, of such a condition will be of proportionately great importance, and a complete understanding of the normal condition of the parts involved will become a *sine qua non* in forming a diagnosis, in indicating the lines of treatment, and in dictating a prognosis.

The display of a suspicious appearance, or an unmistakable departure from the normal condition on the part of the tongue of its surface arrangements as to “fur,” should at once sound “a note of warning” to the observant practitioner and indicate to him that a morbid process is in embryo, or has already made progress along this pathological way. Such displays may vary from the slightest suspicion to the most fully developed example of the abnormal, and their teaching and appreciation become a pathological volume, which has continued to be added to, and more or less scientifically read, since the foundation of the healing art.

The faint suspicion and the fully evolved example of

pathological "fur," as seen on the tongue, alike attest a departure from the normal disposition of that "fur" in anatomical situation and manner of arrangement as to colour, depth, and consistency, usually dependent upon the nature of the diseased condition on account of which they occur, and the profundity of the local disturbances; thus a faint disturbance of the digestive system may only be attended by the merest and most ephemeral formation of "fur," while a suppurative tonsillitis, or quinsy, may develop the deepest, and most lasting, of almost membranous furs—each, however, being alike the consequence of a more or less pronounced stasis of the cerebro-excretory circulation, and a more or less delayed renewal of the final excretory process, due, amongst other causes, to blockage of papillary orifices and inspissation of the excretory material, from osmotic escape of its more fluid parts, through the textural elements of its enclosing and related matrix and superimposed mucosa.

Should these views become a part of our orthodox beliefs, it will again prove that our forefathers, in the art of medicine, based at least one more of their methods of eliciting diagnostic information and indications of treatment on a strictly scientific, if empirical, foundation, and that they were possessed in an eminent or high degree of that professional acumen in reading pathological signs which we are too apt to associate with modern men and times.

Since writing the above, we have been struck with the ideas that excretion from the surface of the tongue of its pituitary residuum must be greatly aided by the continual conscious and unconscious "suction" to which it is subjected in the thousand and one movements in which it takes a part from the beginning to the end of life, the papillary cups and their communicating ductules being emptied and replenished more or less by every such exercise; and that the functional and material value of the excreted material in the process of digestion is certain to be discovered to be of the highest order; a very slight consideration of the circumstances involved in the admixture of alimentary materials and glosso-pharyngeal mucus at once suggesting the accomplishment of profound digestive changes in the elements of food, liquid and solid.

EXTRACT LII.

ON THE PERINEAL RAPHÉ IN THE MALE.

WE have not hitherto been able to secure an exhaustive description of this structure in any of the anatomical treatises with which we have been supplied. We, therefore, purpose considering shortly what it is, and what purposes it serves to fulfil, anatomically and histologically.

Histologically it may be regarded as composed mainly of elastic or fibro-elastic tissue, arranged somewhat in the form of a broad fan-shaped band, extending from near the anus posteriorly to the root of the penis anteriorly, dipping into the perineal structures in its path across the posterior and medial portions of the perineum, and thence through or across the whole extent of the antero-posterior diameter of the scrotum, and upwards through the whole depth of that structure, finally attaching itself to the floor of the pelvis, and thus dividing the perineum and scrotum into two equal parts, sides, or halves.

Hereby, it will be perceived, a surface of central attachment is afforded for the plentifully developed fibrous and contractile, fibro-elastic, and muscular tissues of the perineum, and a fulcrum, so to speak, secured, by which these structures can operate in the contraction and dilatation or relaxation movements of that region—such, for instance, as are to be witnessed under the influence of cold or heat, as in a hot or cold bath, when the former relaxes the perineo-scrotal tissues, and the latter contracts them, until the *raphé* stands out as a prominent band or ridge, and the skin of the scrotum on either side of it is drawn into a multitude of wrinkles.

This latter scrotal shrinkage or contractile phenomenon may conceivably, under active functional circumstances, aid in the forcible excretion or ejection of the testicular contents.

The fibro-elastic and muscular fibres may be regarded as mainly distributed in a double fan-shaped manner, so to speak, over the two halves of the perineum, and operating from the *raphé* centrally, both in its superficial and deep extensions, they exercise the function of lessening the superficial area of the scroto-perineal surface, and hence must lessen the cubic quantity of the fluid and plastic contents confined within it, including the testicular.

In fact, it would seem, or it might be inferred, that the testicular organisms are encircled by these structures, and that they are peculiarly under their influence mechanically in all their phases of functional activity and inactivity.

We may, in connection with these remarks, regard it as a strange coincidence that a *raphé* may also be observed in the *upper lip* in certain people, as if to afford a more firmly organised point of central attachment for the *orbicularis oris*, in its function of contraction of the mouth and upper lip; but the occurrence, it seems to us, may also point back to an early condition of threatened *cleft* in embryonic or early foetal life.

The perineum may be regarded—if the foregoing views be accepted—not as a complicated series of dependent layers of structure only, adapted for a floor to the pelvis, with its contained organs, but as a highly organised arrangement of parts, with anatomical mechanisms, for the control of the great exits from the body, and with physiological structures and functions of the highest order for the maintenance of health and the propagation of the species.

Thus the functions of excretion from the cerebro-spinal cavity, through the *filum terminale*, coccygeal glomerulus, and peri- and endo-anal “modified sweat glands,” the functions of intestinal evacuation and micturition, with the associated functions of testicular evacuation or excretion in the male and parturition in the female, and the organisms by which these offices are effected, all find the “theatre of their operations” on, within, and through

the textures of the perineum and associated anatomical parts.

It was suggested that the ejection of the testicular contents was, to a considerable extent, assisted by the inherent contractile powers of the scrotal sac, owing to a property of contractility, akin to that of muscle, with which its component fibres are endowed, and which act under the apparently combined nerve stimuli of the sympathetic and systemic nervous systems.

The other great excretory acts in which the perineal and adjacent structures have from time to time to be engaged, viz. those in which the bladder and the bowel are respectively engaged, if we patiently analyse them, will be found to be similarly determined, although carried out on their own distinctive lines, as determined by the particular viscus involved, and, consequently, the nature of the excretory acts. Occupying, as they do, the floor, or most dependent part, of the human body, and, therefore, the situation best adapted for the occurrence of the two great functions of excretion proper, as well as the somewhat kindred functions of menstruation and exfoetation or child-bearing, we find laid down on their supporting textures a system of storage and disposal structures which, for combined simplicity, complexity, perfection of structural arrangement, and the adaptation of "means to ends," may be regarded as unsurpassed in the whole array of *designs* observable within the human economy.

Each of the viscera concerned, being a storage organ or space of limited capacity, requires to be possessed of the power of emptying itself when the limit of that capacity has been reached. Consequently, we find that it responds first to the unconscious influence of sympathetic nerve impulse, due to afferent or sensory influence, and consequent reflex or efferent stimulus, to the involuntary musculature implicated, through the sympathetic nervature; and, secondly, in consequence of this, to an appeal to the systemic nervature, which brings to its aid the connected voluntary musculature, wherever available, throughout the abdominal walls, and even more distant parts. This compound nerve disturbance, or sympathetico-systemic nerve storm, and accompanying muscular

contraction of the combined striped and unstriped musculature, is usually effective in accomplishing its object, but is sometimes attended or followed by a considerable degree of exhaustion or collapse, which is suggestive of a great expenditure of energy, nervous and muscular, and at times an accompanying leakage of sympathetic nerve energy into the systemic nerve and muscular structures, which may be quite consciously felt and appreciated, more especially throughout the lower extremities.

It might here be remarked that a singular parallelism is established, but in inverse order, between the neuro-muscular phenomena exhibited in the act of deglutition on the one hand, and the acts of rectal and vesical excretion and uterine contraction on the other, in the former the systemic neuro-musculature initiating the procedure, and in the latter, the sympathetic. These combined systemico-sympathetic neuro-muscular activities illustrate also the oneness as well as the duality of the nervous systems, and the mutual or independent relationships manifested by the combined nervous system in all its more complicated physico-mental operations and processes.

EXTRACT LIH.

ON THE PHENOMENON OF CILIARY MOVEMENT IN THE CIRCULATION OF CEREBRO-SPINAL LYMPH, AND OF AIR AND MATERIAL PARTICLES IN THE LUNGS.

WHETHER ciliary movement of the lining membranes of the early, and of even the later circulatory passages of the embryo, always occurs as a phenomenon of circulatory assistance, it is difficult to say, but it is true that the phenomenon occurs during or in its latest stages of growth, and becomes more and more obvious as early foetal life progresses. Thus, at that stage, when the neurenteric canal becomes divided into neural and enteric, and when the free and general circulation of its enclosed lymph, which has hitherto been allowed to occupy the whole lumen of the canal, gives place to a very restricted circulation at the line of division, which to some extent is compensated for by the opening up of an anterior means of circulation and evacuation, by which the narrowing lumen of the neural canal is maintained in physiologically necessary patency and fluidfulness, to meet the varying conditions and wants of the evolving systemic nervature, cerebral and spinal, there is noted a growth on the lining membrane of the whole future cranio-spinal inter-spaces of a ciliary prolongation of the surface cells, in order to aid in the process of the, then comparatively passive, lymph circulation.

In the ventricles and central canal of the cord, as they become evolved by the increase of the true nervine

elements and the consequent shrinkage of the intra-cerebro-vesicular cavities and the medullary canal, gradually appear the ciliary projections on their lining epithelium, as well as on that of the evolving coccygeal gland and of the pituitary body on both ends of its developing elements, *i.e.* both from within the infundibulum on the one end and the buccal cavity on the other.

What does all this mean? Simply, what the appearance of a ciliary lining membrane always means, that it has been developed or evolved for the purpose of aiding and maintaining circulation along open passages or constricted lumina, where gravitation, capillary attraction, and other physical agencies require such assistance. We must, therefore, recognise in this very early appearance of this circulatory adjunct, that the principle of circulation, wherever it has appeared, is the greatest function subserved by the cavities, or passages, involved, and that, if it were necessary to use this fact as a histological evidence of the claim, which we elsewhere advanced, for the truth of cerebro-spinal lymph circulation and excretion, we are absolutely entitled to it for such a purpose, for, no doubt, were we meeting it "for the first time" in any hitherto unknown line of research, we would be warranted, nay, compelled, to give a reason for its existence.

Moreover, the occurrence of a pre-natal ciliary epithelium on the lining membrane of the naso-pharynx, and the glosso-œsophageal mucosa, speak of a continued passage of material from the central brain spaces through the intervening uniting structural media, established for the great functional purpose of conveying into the stomach, when deglutition was both structurally and functionally impossible, the residual products of brain waste to become part of the meconial mass occupying the alimentary canal, when as yet no substance of an alimentary character had been admitted thereto. At this stage of foetal existence, the greater part, or, it may be, the whole of the circulatory work between the cavities of the skull, the mouth, the lungs, and the alimentary canal, is due to the action of the ciliary epithelium and underlying mucosa of their lining textures.

Post-natally, an alteration takes place in the lining

membrane of the nares, mouth, pharynx, œsophagus, stomach, and lungs, by which much of their ciliated epithelium is modified or abolished, but the discharge from within the cerebro-spinal cavity still continues to be aided by it, until the clogging effects of advancing life gradually usurp the conditions of early freedom and physiological activity—so far as ciliary agency is concerned—by which time the processes of mastication, insalivation, pituitarisation, and deglutition are capable of effecting the same end by more decidedly musculo-mechanical means and superadded digestive agencies.

It is noteworthy, too, that such inter-current lymph channels, as the lachrymal sacs and nasal ducts and the Eustachian tubes become lined with a ciliary epithelium, so as to facilitate the movement of fluids, with dissolved or suspended materials, through passages, or structures, which are not contractile, and hence are merely passive and vehicular, in relation to their circulating contents.

Viewed thus, it becomes abundantly obvious, and in fact absolutely evident, that no such thing as a cerebro-spinal “shut sac” can possibly exist, but, on the contrary, that a circulatory régime of a most apparent and “absolutely adapted” character subsists throughout the whole nervous system, by means of which the great desiderata of fluid mechanical support, equalisation of intra-cranio-spinal pressure, and physiological hygiene, are simultaneously secured and maintained, quite “in keeping” with the requirements of the great central or blood circulation, and the many other minor and less apparent circulations to be found throughout the human organism.

What more ideally adapted means for the keeping clear of the cerebro-spinal lymph “highways and byways” than the “sweeping apparatus” of an epithelial lining membrane, the ciliary processes of which are in continuous movement, with the result of regular forward progress of the circulating fluid, and, it probably may be, its retrograde movement, when circulatory progression becomes stayed or reversed? Outside the “sphere of influence” of the heart’s impulse, when circulation is reduced to a great extent to “vegetative” proportions and methods, we see at work a most wonderful array of circulatory

expedients, but none more structurally advanced, or more highly functioned, than that of the apparently "self-determined" ciliary movements of the lining epithelial and endothelial cells of the various passages, tubes, and ducts, through which course air with suspended particles, or fluids with dissolved or suspended matters.

EXTRACT LIV. A.

ON SOME OF THE SALIENT POINTS AND DEPARTURES
FROM ACCEPTED TEACHING INVOLVED IN THE
FOREGOING VIEWS: CIRCULATION.

THESE mainly group themselves around the doctrines of circulation and nutrition, with the related subjects of secretion and excretion, the histology of cell and fibre generally, and that of the sympathetic and systemic nervous systems particularly, the hydrostatics and hydrodynamics of the lymph, or fluid called cerebro-spinal, of the central cerebro-spinal nervous system and its related peripheral and sympathetic extensions, and the bearing of them on the causation and incidence of clinical and pathological phenomena. Thus grouped, they pertain both to structural and functional matters, as observed in the human organism in particular, but they are applicable to all dually innervated and animated beings.

The principle of circulation determines the manner of occurrence and sequence of all the materio-dynamic phenomena of life, and is operative alike in the uni-cellular ovum, in the embryo, and in the adult body; in the first by molecular movement on atomic lines; in the second by, or along, rudimentary vessels; and in the third through the agency of elaborated and organised vasculatures, the materials moving, or circulating, in the minutest physical division, or as capillary filtrate, in molecule, and as vascular fluids, in mass, respectively,—these three methods of distribution of organic pabulum or plasma being conjointly utilised for the accomplishment of the whole phenomena of nutrition, including those of metabolism

proper, secretion, and excretion. Physiological chemistry here works out, together with mechanical movement and displacement, the complicated processes of tissue integration and disintegration by virtue of those affinities and repulsions, so familiar to the students of matter directed and determined by the dynamics of neural and general life for vital, or organic, ends and purposes.

Circulation, as thus observed in the adult organism, in the sequence of its events, culminating in the metabolism of the tissues, is carried on through a series of vascular media, consisting of the alimentary canal, the chyloferous vessels, the blood-vessels, systemic and pulmonary, arterial and arterio-capillary, cellulo-osmotic and inter-cellulo-fibral, or anabolic, the whole series terminating in the completed metabolic or nutro-integrative, the latter dovetailing with and beginning the katabolic or nutro-disintegrative, consisting of the capillo-venous, the venous proper, the lymphatic, dextro-cardial, and pulmonary. These vascular, or circulatory, media consist of a graduated series of organised vessels of definite lumina of separating and uniting membranes with meshes *permeable* by osmosis and of connecting fibres *passable*, or *permeable*, by the nutritive plasma, and its residual or waste material results.

The dynamics of highly organised forms of multi-cellular life again emanate from, and are supplied and sustained, uni- and multi-cellularly, by the two nervous systems—the sympathetic and the systemic, their manner of application to the vital necessities of the living organism being known by the name innervation. This innervation may either be systemic or sympathetic, individual or conjoined, according as the requirements of the body for the time being necessitate, and there is also good reason for supposing that nerve energy can be drawn simultaneously, when necessary, from one or the other, or both, as local and general vital requirements necessitate for the time being.

Organic life is the peculiar field for the operation of sympathetic innervation, while cerebral and cerebro-spinal vital activity is the peculiar domain for the exercise of systemic innervation, the former being uninterruptedly in use from the beginning of life till its close, the latter only

in the waking condition of the body, or, say, two-thirds of life only.

To enable the great neuro-dynamic generator and distributor, the brain and cord, or cerebro-spinal centre, to perform its work, free from disturbance from without and from within, it is housed, so to speak, in a disturbance-proof retreat, within the domain, and under the influence and innervation, of the sympathetic nervature, surrounded and inter-penetrated by an aseptic and hygienic fluid, which is responsive to every mechanical impression from within and from without, and possessed of the power mechanically to take up, and remove, all material residual products, begotten of neuronal waste, or due to neuroglial overplus from neuronal non-utilisation.

The hydrostatics and hydro-dynamics involved in the local and general disposition of the cerebro-spinal fluid within the sub-meningeal spaces, the cerebral ventricles, the central canal of the cord, and inter-neurilemmar sheath spaces of the nerves, sensory and motor, are nothing short of the first importance in the maintenance of cerebro-spinal and neuronal functional completeness and structural integrity, as well as physiological hygiene, within the precincts of the systemic nervous system, hence any local or general lapse, intrinsic or extrinsic, of them may lead to the incidence of pathological phenomena, and the development of clinical or morbid entities.

While the disturbed hydrostatics and hydro-dynamics of the cerebro-spinal fluid may thus give rise to mechanical conditions, productive of pathological and clinical results, alterations in physical and chemical qualities and bacterial interferences with its essential characteristic of asepticity may originate a category of diseased conditions nothing less than astounding, which, therefore, calls aloud for the closest study of those engaged in the fields of practical neurology and psychological medicine.

In whatever part of the organism we may study the phenomena of circulation, we will find that the primary condition of physiological health therein is based on the *constancy* of that circulation in its normal ordered and forward flow or movement, and that the first sign of pathological change is found in, or to emanate from, stasis, or regurgitation,

a condition which necessarily affects ultimately the vitality and health of the area involved in the occurrence, and also, necessarily, the neighbouring areas so far as their histological continuity and functional relationships determine. The same doctrine holds good whether we regard circulation in its uni-cellular, multi-cellular, or organically and viscerally grouped aspects, and points to the absolute necessity of, at all times, discovering its *locale*, and securing the patency of the channels beyond, or ahead, of the site of stasis or regurgitation, and thus of providing a way of normal progress for the circulating materials, whether they be nutrient or effete, so as to allow of the effects of the temporarily evolved morbid incidents to be effectually dealt with by the *vis medicatrix naturæ*.

When this has taken place, and all the circulatory media being, or having become, unexceptionable, we shall be prepared to see, so far as circulation can determine, a condition of perfect functional work, but where irremovable error has crept in to mar that perfection, we may, likewise, be prepared to find that that error is to be found, very often, wherever *linkage* of these circulatory media takes place, or at the points of alteration of lumina of channels, or altered physical consistence and physiological condition of circulating material; such, for instance, as may be found, where the alimentary materials are taken up by the gastrointestinal mucosa, where the chyloferous vessels pass through their associated glands, in the capillary areas of the lungs, and peripheral capillary blood vasculature, the incipient lymphatic vasculature, where its lumen is valved, or passes through glands, as well as at all those points where the various great excretory agencies converge and eliminate the residual products of sympathetic nervine activity and vitality. Besides the foregoing, and very specially in the systemic nervature at its source in the neuroglia of brain, cord, and ganglia, at its points of axonal fibre interruption or junction, and at its peripheral terminations, sensory and motor, or where linkage of its neural elements is effected with the skin and muscles, it displays a like liability to circulatory stasis, and a consequent tendency to pathological change and morbid genesis.

As a line of principle for enabling us to trace the

incidence and progress of disease, we therefore claim that we have here, based on histological data, a means by which we may more scientifically diagnose many ailments of the most profound order, and be enabled to direct their treatment on less empirical lines than we now are wont to do.

Moreover, we think it would not be too much were we to claim a large portion of the group of new growths, or tumours, as examples of *faulty tissue linkage* between the two great systems of innervation, where, and by which, the normal formative energies of the great organic or vital machinery are directed along new and strange lines with the quite natural, but pathological, result, that the natural formative processes are followed by new and strange tissue forms and structures, which are generally known by the names of the normal textures in which they originate, or from which the formative impulses are derived, and from whose formative plasma they obtain their support, material and dynamic. By an extension of this theory of the origin of disease, or pathological change, to the class of tumours known as malignant or cancerous, we have but to assume that further pathological changes are effected by the addition of fresh morbid, or intensified pathogenic formative, impulses and pabulum to the specific work of the already discordant elements, and that a consequent continued further departure from the normal character of the original structures involved takes place, during which it may be that every trace of the original structures is destroyed, and an absolutely foreign, but pathologico-physiological, structural element alone is left to occupy the tissue spaces of the hapless host and to destroy its life.

We furthermore would add, that that parallelism, or synchronicity, which should characterise the cessation of function, and the removal of disused structure, is alone possible when the circulatory ways are "straight," and where the *vis medicatrix naturæ* can effectually assert itself in the maintenance of "a clear bill of physiological health," by a dynamic superiority of influence over all interloping pathogenic agencies, be they physical, chemical, or bacterial, or misdirected formative impulses, and consequent neoplastic developments.

Visceral and textural limitations, or boundaries, and fibro-muscular attachments forming inter-textural frontiers, or boundary lines, of compoundly innervated elements, lend themselves to circulatory disturbances and stases, and so afford "backwater eddies" of debatable plasma and of questionable character, so to speak, in which the dynamic and material factors of disease are allowed, it may be, a momentary and precarious footing, but in which, if the tone of physiological health, local or general, happens to be lowered, that footing may be sufficient to allow of a beginning in the process of pathogenesis and the evolution of definite disease; the character of which latter will be regulated by the factors in operation and the structural elements involved,—so-called functional disease being from this point of view an impossibility—the truth of which statement, were we possessed of sufficiently effective means of observation, would necessarily be discovered and made available for practical materio-dynamic purposes. Disease is thus the outcome of abnormal dynamic and material agencies, working primarily along normal, or physiological, lines, and the expression in new forms of growth of the results of determinate formative materio-dynamic activity, each new form taking on the character of the predominant physiological factor or factors, and local structural conditions, material and dynamic; thus, neuroma is the outcome of a stasis of neural circulation and accumulation or growth, and indicates quasi-organisation of the axonal fibre medullary material within the peri-neural sheaths, while true sarcoma is due to a stasis and new formative arrangement of the elements of muscular tissue within the structural limits of conformable textures, and so with the other varieties of new growth.

EXTRACT LIV. B.

ON SOME DEDUCTIONS FROM THE FOREGOING STUDIES IN THEIR BROAD AND GENERAL BEAR- INGS: NUTRITION, INNERVATION, ETC.

It is a truism to say that in the human body we have to deal with only two entities, viz. energy and matter, but energy and matter in transcendental relationships to each other, the result being the development, production, or evolution of an organic entity *sui generis*, and altogether unique in the known realms of nature.

Energy and matter, whether they be found ultimately resolvable and interchangeable entities or not, exist sufficiently apart from each other here as to necessitate their individual recognition as co-partners in the production of the human being, and, for that part of it, of every organic unit throughout the universe, hence, we think, that it may not be altogether unprofitable if we study them individually, and as related genetic elements and co-efficients in the production and evolution of human life, and as the determining agents in the maintenance of that life, as well as in the initiation of the diseases to which the human body is liable, and which usually terminate its duration.

As to matter, it may be said that, even before so-called scientific times, it has been recognised as the basis of organism, as well as the substance of the soil and the matrix of the "everlasting hills." Since the advent of science, however, it has had a specific meaning, or signification, assigned to it, which has raised it to the position of one of the partners in all the material or tangible

developments of the universe, those of organic nature included.

Thus regarded, the entity matter seems the more passive partner in the working of organic activity, lending itself merely to active change of form and arrangement, under the resolvent influence of energy, and comporting itself so as to allow the combined business, so to speak, of the partnership to be conducted to the greatest mutual and individual, as well as general, advantage, for specific ends and purposes, temporary and more permanent.

Energy, however, was long comparatively ignored by the world at large, or, if dimly perceived, was so overshadowed by its more apparent partner matter, that its qualities and attributes are now only being gradually appreciated by the powers of science, and brought home to the intelligence of that world, by their scientifically directed and utilitarian application to its everyday necessities. In the human organism energy and matter are united in all the vital work characterising it, in subservience to the behests of intrinsic and extrinsic necessities, and it is only by that human organism that the highest physico-psychic attainments have been reached in the organic world, and that the "confines" of the immaterial, metaphysical, and theologically recognised spiritual universe have been entered, and to some extent traversed. The mode of energy called "vital" inter-penetrates the formative or protoplasmic matter, and organically "inspires" and arranges it to suit the developmental requirements of the living and growing organism of man, beginning its proper operations in the primordial particles, set apart by appropriate selective provision for the propagation of the species, and terminating them sooner or later with the death or devitalisation of the more or less mature, or perhaps senile, individual organism. This vital energy must, necessarily, be primarily imparted to, and must co-incidentally determine, the primary molecular arrangement of germ and sperm cell materials respectively, each of these supplying thereafter its contribution of formative plasmic elements to the common resultant uni-cellular organism.

The uni-cellular human organism being thus materially

and dynamically the result of the combination of two formative bodies, each of the most highly specialised and potential character, possesses within itself, besides life, the ability to undergo, with the aid of the maternal structures, and vitality or energy, changes fitting it for a multi-cellular existence and ultimate independent life.

The uni-cellular body lives and has its being in virtue of its molecular material basis, being energised, or innervated, and organised by its originally contributed or innate energy, supplemented in time by union with the material structures, and the pseudo-parasitic acquirements, from this source, of both energy and matter. In its earliest, or uni-cellular, condition, it is thus innervated, or energised, by its own intrinsic force, through the special molecular arrangement, or organic disposition, of its substance, in such manner as affords the necessary facilities for the exercise, or operation, of the inherent and inherited intra-cellular formative impulses.

The entry of the sperm into the germ cell determines, or initiates, the phenomena of intra-cell circulation, innervation, and development, by the introduction into a hitherto passive body of an active nucleus and formative impulse, and by the bringing into direct contact, and within the range of influence of mutual affinity, highly energised, and vitally active, materials, and marks the beginning of the evolution of the complex mechanisms known as alimentary, circulatory, and nervous systems, which form the machinery of the succeeding stages of multi-cellular and embryonic development, and foetal, independent, and adult life.

It therefore goes without saying that uni-cellular is co-extensive and synonymous with intra-cellular life here, and that all the attributes of organic activity, and the display of vital phenomena generally, are manifested, in miniature, within the precincts of such uni-cellular organisms, the material changes and exchanges being conducted in molecular and atomic proportions, and the dynamic phenomena displayed being measured on the same scale of magnitude. Within each such organism, it follows that all the material or metabolic arrangements, and re-arrangements, take place along certain definite lines or channels, the

lumina of which are of atomic proportions only, by the influence of dynamic impulse and propulsion, determined by physical, chemical, and vital necessities and laws, as bindingly and exactly operative as are those displayed in any other department of organic nature; in this uni-cellular organic microcosm, moreover, we see the cell phenomena of plant and animal life generally "anticipated" on the minutest of scales, the substance of the cell plasma circulating within it, from one atomic space to another, by intra-cellular dynamic agency, very much in the same manner as tissue plasma is conveyed from cell to cell by inter-cellular dynamic agency along the inter-cellular canaliculi, commonly known as cell processes or intercommunicating fibres—not solid, but, as we think and contend, hollow tubes or porous textures. Circulation, therefore, manifests itself from the first instant of uni-cellular life throughout the whole area of intra-cellular space and substance, and is determined and sustained by the dynamic and evolvent influence of the inherent energy of the organism for developmental purposes and ulterior organic ends, innervation being thus also "foreshadowed," and the complex process of metabolism and nutrition fully and clearly displayed in their elementary and simplest forms.

It thus becomes evident that human uni-cellular life originates, or begins, in virtue of the co-existence in the fecundated ovum, or combined germ and sperm elements, of an initiative developmental power, energy, or dynamic influence, whereby these elements are histologically or molecularly arranged in such order and sequence as to permit, and determine, a regular and coherent process of formative growth and development, capable of leading to similar, but further physiologically diversified multi-cellular structures, according to definite plans, and with definite objects or purposes. The parentally imparted energy, thus employed, arranges the matter of the ovum, or fecundated cell, into rudimentary organic units or molecular groups in pseudo-fibral form, each constituent molecule of which, after having subserved its organic purpose, becomes used up, and has left a structural void, being replaced by another, thus initiating or founding the

principle of circulation as one of the active determining factors in the economy of nutrition or metabolism.

The process of uni-cellular material circulation is effected, in virtue of the pseudo-fibral, linear, or successional molecular arrangement, of the intra-cellular substance, and necessarily, therefore, along "the lines of least resistance," secured by such developmental disposition, determined and operated by its specific or innate energy, and supplemented by the necessary surrounding maternal conditions, material and dynamic. Intra-cellular circulation, therefore, consists of the processional movement of the intra-cellular contents along definite lines, secured by definite developmental provisions, in obedience to definite "vital laws" and requirements by "vital dynamics"; these latter, or "vital dynamics," being so specific and *sui generis* as to partake of, and transcend, all the dynamics now known to science. Innervation, in a word, is the *dynamic sine qua non* of life, or the active vitality; without it, the future or possible live elements of organic matter refuse to alter their still inorganic character and arrangement, and continue to yield themselves to the continued domination of inertia and other ordinary inorganic laws; but with it, and favourable conditions for its operation or exercise, the elements, as by enchantment, assume the conformation and characteristics of living forms, yielding themselves to its behests, meeting its every requirement, and partaking in its conquests of vitality and organic order over dead matter and inorganic forces.

As the dynamics of the fecundated ovum, in its intra-cellular life, are due to, and operated by, innervation, so they continue, in its kariokinetic divisions, to dominate the individual life of each of these divisions or units, and by nervine combination of them, to direct their life and work to the accomplishment of common, developmental, and functional ends, until the resultant multi-cellular organism assumes proportions, requiring its division in turn into organs and systems requiring more or less specific and individual innervation.

Innervation is, therefore, divisible into intra-cellular, inter-cellular, and inter-systemic systems, according as vitality is existent and operative in cell, multi-cell, or

systemic organisms and proportions for the time being, and is capable of meeting the dynamic wants of one, more, or all of these organic conditions, individually and collectively, in every conceivable situation.

While circulation characterises the manner of disposal of matter within the living organism, so does it characterise that of energy, both being amenable to the control of the same laws, for the accomplishment of the same purposes or for common ends. Thus the material and dynamic activities of the cell constitute its *raison d'être*, whether it begins and ends as a uni-cellular organism, or, by mitotic continuation, becomes the instrument, through evolution, of founding a multi-cellular organism, while, in turn, the multi-cellular organism, retaining its connection with its uni-cellular parent, by cell processes through which innervation of the common cell colony is maintained, perpetuates, by continuity, the effective operation of the same activities, material and dynamic.

Circulation, thus far in the organic scale, is merely intra-cellular and inter-cellular, and, therefore, is determined and operated by the inherent nervine energy of cell and cell group on principles emanating from uni-cell and multi-cell sources, and, therefore, devoid of any central nervine control, productive or distributive; it is, however, the circulation on which the organic life of man is dependent, and by which he is able to maintain the working of that vast machinery amid which his central nervous system has ultimately to be placed for the accomplishment of his highest terrestrial destiny.

Circulation and innervation, being alike the possession of cell and multi-cell organisms, it becomes apparent that metabolism and nutrition, the processes by which life is maintained, must be directly related to them in the way of cause and effect; if so, we must therefore be prepared to find that *the channels of least resistance*, along which the circulation of the two entities—matter and energy—must and can only be those channels; it, therefore, further follows that the material circulated can, and must, only be the plasma or pabulum from which the nutritional elements are supplied, and that its vital distribution and organic disposal is the principal function of innervation—

the modes of nervine energy being exercised in the uni-cellular organism in molecular proportions, and in the multi-cellular organism in cellular proportions. In the former, or uni-cellular organism, nutrition, therefore, begins with and consists in, the neuro-dynamic conveyance of the material elements of the structureless cell protoplasm to the nascent structural developmental areas, and its disposition there in the proper molecular and atomic vacuoles reserved for its reception, through the reticular pseudo-fibro-vasculature, which gradually appears throughout the body of the cell. In the multi-cellular organism, while the uni-cellular, circulatory, and neuro-dynamic machinery is retained and continued in active employment in maintaining the vital integrity of its individual cells, an inter-cellular, material, and dynamic machinery is evolved and maintained as each mitotic division of the growing cell community takes place, which ultimately assumes the proportions and extent of a nervous system, and which, in the higher animal world, is recognised as the sympathetic nervous system.

This description of nutrition involves the idea that the developmental and nutritive pabulum *exists in non-detectable intra-spaces within the apparently homogeneous matrix* of the cell body, which, on the application of the necessary distributive dynamic agency, takes its place in the appropriate intra-cellulo-organic spaces, *to be renewed by nutrition* as it becomes worn out and displaced; as well as the further idea, that within the cells of the multi-cell organism, individually and collectively, there exists the pabulum required for the development, growth, and nutrition of that organism, both in its cellular and non-cellular, or fibral, textures and nascent organs. Moreover, it seems justifiable to conclude from these premises that intra-cell spaces of uni-cell bodies, and the cell cavities of multi-cell bodies, are but receptacles, or cisterns, of nutritive plasma, which can be drawn from, as the exigencies of nutrition require and determine, by the proper nervine detective or selective agency, and dynamic impulse, along the neuro-fibral pathways, or inter-cell processes, whose patency or porosity secures the necessary vasculature for inter-cell material change and exchange. The *raison d'être* of the

cell is thus made more manifest when we consider that the nutritive sum of the gross pabulum of to-day with which we supply our bodies, after manifold physical, chemical, and physiological change, is stored up, or deposited, throughout the entire cell intra-spaces of these bodies to become the supporting medium of their whole structures and organs to-morrow.

Nutrition thus manifests itself within the human body as a uni-cellular, multi-cellular, and inter-systemic phenomenon, accordingly as it is viewed, elementarily or systemically, embryologically, or within the fully developed body. It is due to circulation and organisation of plasmic material, actuated and determined by innervation, or the play of vital energy, within a suitable body on suitable alimentary matter—that matter undergoing change, under the influence of vital energy, from its originally inorganic condition to its fully organised form, through the phases of alteration of its atomic arrangement and molecular disposition, its granular rearrangements, cellular developments, textural fabrications, visceral organs, and ultimate systemic combinations.

As a uni-cellular phenomenon, nutrition consists in the imbibition by the cell wall endosmotically of the required alimentary plasma, and its metabolic disposal, and, synchronously, in the excretion exosmotically of effete and non-nutritious material, by the operation of its innate vital, selective, and katabolic energies. As a multi-cellular phenomenon, it consists of the above uni-cellular nutritive method, conjoined with inter-cell distribution of nutritive plasma by means of cell-communicating processes, each cell passing on that plasma to the cell, or cells, with which it is united, until the entire related cell community has had its nutritive wants met. Like uni-cell metabolism, the multi-cell metabolism must comprise and synchronise with the removal or excretion of effete and useless material into the extra-cell spaces and lymph areas for removal, to the end that nutritive circulation should not consist in the redistribution of such probably, or potentially, toxic elements. Pursuing the subject, we see that again inter-systemic or pan-systemic nutrition is effected by both of the foregoing methods, conjoined with the specially and

finally evolved hæmal and systemic nervine circulations and nutrition, which are the last to appear of the three systems of circulation and nutrition—the three systems appearing at three well-marked epochs of developmental progress in the growth of the human organism, and synchronising, first, with the coalescence of the sperm and germ elements of the ovum ; second, the earliest mitosis of the uni-cell ovum ; and, third, the primary arrangement of these mitotic multi-cell elementary textures into definite organic or histological tissues and organs for definite physiological or systemic purposes. Thus, from the most elementary to the most complex tissue conditions characterising the development and evolution of the human body, nutrition is effected on the definite lines of circulation and innervation, inspired by life or vital energy, which suffice both to initiate and maintain it so long as the necessary material and dynamic conditions are supplied and the requisite intra-organismal or physiological health is maintained.

These three methods of nutrition, although appearing at definite developmental epochs, continue to take part in the accomplishment of the one general work ; that general nutritional work being intra-cellular, inter-cellular, and systemic in its manner and method, and requiring for its accomplishment the simultaneous operation of the three. Three planes of formative or vital activity are herein represented, viz. the molecular or intra-cellular, the granulo-homogeneous or fibro-inter-cellular, and the corpuscular or hæmo-vascular ; but to these three planes has to be added the highest plane of all, the nutritive and circulatory phenomena included in the *tout ensemble* of the vital work of the human body, the specifically nervine or neuro-psychic.

The nutritive plasma, at the stage of embryonic life when the first three methods of nutrition are combined for the general purpose of growth and differentiation of component structures, is conveyed to the embryonic organism, fully prepared by the maternal organism, and requiring only to be assimilated by its formative economy ; at the stage of post-natal development, however, when the infant organism has to prepare its ingesta for absorption into its hæmal circulation, and

assimilation by its various textures and organs, the fourth method of circulation and nutrition comes into fuller and fuller operation, until, to a great extent, it overshadows the first three ; but here, nevertheless, as between the first three, the principle of union and co-operation for common ends marks its advent into the combination and the working of the future organism.

The nutritive plasma is prepared and passed through an alimentary tube by a highly organised series of circulatory structures, preparatory to its absorption into, and vitalisation by, the hæmo-genetic economy, after which the various methods of nutrition are resorted to and the wants of the whole organism are met by its passage into cell, related cells, tissues, and organs by the methods of circulation and nutrition, just described, under the dynamic influence of innervation, intra-cellular, sympathetic, and systemic.

The various planes of nutritive activity, actuated by these various methods of innervation, are represented by the formative growth and organisation of certain structural bases ; thus, the uni-cell meets the necessity of the first plane of nutritive work, the multi-cell community the second, and the systematised arrangement of cell communities the third, while the fourth has a huge matrix of faintly organised material in the form of the entire neuroglial substance from which to extract the elements of its growth, development, and nutrition, as well as those required for the growth, development, and nutrition of skeletal muscle, and related, or histologically continuous, textures, periosteal, osteal, and others.

The plasma for the last, or systemic nervine, method of nutrition, is deposited by the *pia mater* from its hæmal vasculature amid the inter-spaces of the dense fibro-cellular feltage of the neuroglial matrix, where it is constantly available for purposes of neuronal nutrition and neuronal protection as well ; each neuronal unit supplying itself by its own absorptive economy from the common neuroglial store, and passing its used-up material on to its terminal distribution for final excretion and disposal by its afferent, or efferent, end organs, as the case may be.

Throughout the whole of this nutritive economy, it will be observed that the cell nutritive method is the foundation of all the nutritive methods and that uni-cellular nutrition but repeats itself in every alteration of method, the principle of uni-cell innervation being also repeated, while the addition of a multi-cell system, and proper nervine methods of innervation, are also repeated and maintained as the widening range of organic activities increase, and the necessity for organic division of labour forces itself on the formative and nutritive determinant materio-dynamic, or central, mechanism of life.

The independent, or uni-cell method of nutrition, merges into multi-cell methods, which in turn develop into inter-textural and inter-organic, or vascularly united nutritive methods—the last mentioned being followed by the nervine, or neural, proper methods, each flowing out of the other as the conditions of the life of the organism alter in complexity, and as differentiation of its component parts necessitate increase and elaboration of its dynamic and circulatory, or nutritive, machinery. It thus follows, that each system, or method, of nutrition is self-determined and actuated, inasmuch as the most elementary and simple of the various systems, or methods, enumerated proceeds, and gives origin to, the more complex, the prerogatives of each system being retained and utilised by the others, until they all merge into one systemic whole, in which the widest individual freedom is allowed, consistent with the united welfare of the completed communal organism.

The relationships, therefore, of *the reputed cerebro-spinal trophic centres* must be assigned a position in the economy of nutrition of a relatively much more restricted character than that now in vogue; inasmuch as the three first methods of nutrition can be, and are, under many circumstances, both physiological and pathological, absolutely alone, in determining and maintaining the operation of the process of nutrition of cell, tissue, and organ—the *systemic neural element* in that process, for the time being, completely disappearing, to be renewed in the former, or physiological, but often never to be renewed in the latter, or pathological, condition.

Thus, it follows that nutrition, of the non-systemically innervated structural elements of the body, is accomplished by non-systemically innervated means, and that the nutritive rôle of the systemic nervous system is restricted to the neuro-dermal and the neuro-muscular and skeletally continuous or related structures. It may be claimed, however, that the inter-relationships of non-systemic and systemic innervations are so intimate that a definite connexus, or a system of material and dynamic continuity, pervades the entire areas of innervation and nutrition, whereby a common system of material and dynamic circulation is maintained throughout the entire body, securing its vitality and functional integrity from uni-cell to completed organism, so long as the conditions of life of the units subsist.

In all this we see alone the mechanism and working of life, but do not once detect the great entity known as life itself: like a watch, which we energise by a few contractions of our arms and muscles and turns of a key, and set moving in its determined way, so life is the dynamic outcome of a supreme influence, or source of energy acting "behind the scene" of human organism, as well as every living organism, and using it and them for purposes and in ways which "we wot not of."

A wide field for pathological research here opens up, where the physiological methods of nutrition become merged in the pathological, often by unbroken material and dynamic links, so seemingly similar that it is impossible, by the knowledge we now possess, to say where the one ends and the other begins—health and disease co-existing in the same organism, and contending for the mastery.

We would further conclude, that health alone can exist where complete separation is maintained between nutritive and effete materials within the areas of trophic, or metabolic, change, and we claim that that is effected by a continuity of *onward circulation* of the materials composing the ingesta and egesta during their intra-corporeal progress and their final restoration to the outer world.

From the conversion of the raw materials of food and drink into arterial blood, and their conveyance into the

matrix of every tissue of the body, a well-marked circulation, through formed or organised vasculatures, continuous the one with the other, takes place, and when they arrive at these tissues their circulation is taken up by cellular agency, and transmitted from cell to cell by connecting cell processes, previous to the passage of anabolised nutriment, the preceding metabolised plasma having been moved on and katabolised, when it is shed into the intercellulo-fibral lymph spaces, gathered into the lymphatic vasculature, and returned into the blood stream to be further dealt with as still useful or altogether effete, while a portion of that arterial circulation is diverted into the *pia mater* vasculature and deposited in the meshes of the neuroglial matrix as the material for the maintenance of the systemic nervous system, another portion being released to form or become the cerebro-spinal lymph—all of which in turn continue circulating until they either are returned directly into the outer world or join once more the great blood circulation to be still further dealt with.

EXTRACT LIV. c.

ON SOME THOUGHTS ON THE GENERAL PRACTICAL BEARINGS OF THE FOREGOING EXTRACTS, AND ON THE UNITY OF THEORY AND PRACTICE.

ONE of the first thoughts to strike us, is the need for uniting the "practical results" of the "findings" of the various sciences, on which the professions of medicine, surgery, and obstetrics rest into one coherent body of doctrine, which shall be at once conducive to true scientific progress, to the satisfying of human necessities and health wants, and that will lend itself under all circumstances to immediate availability. To this end it seems to us that, as heretofore, the foundation for uniting the "practical results" and "findings" of science must primarily be laid, in a full understanding of the plan of inorganic nature and its bearings on the superimposed weight of doctrine, included in the nature and sequence of organism and life chemistry; therefore, natural philosophy and natural history must continue to constitute the foundation, supplying at once the necessary knowledge and begetting the acquirement of familiarity with the use of the "tools" and "methods of handicraft" of abstract and applied science.

On this foundation, it may justly be claimed that all, or almost all, the notable additions to the science and art of these professions have been evolved, and on this foundation have been built up the structures of the various sciences composing medical, surgical, and obstetric common knowledge; it behoves, therefore, all who are engaged in imparting this knowledge to recognise the

important fact that not only the foundation, but a large portion of the superstructure, belongs *in common* to its special latter-day developments. This superstructure of common knowledge, consisting of anatomy, histology, physiology, and pathology, raises the edifice of medical, surgical, and obstetric teaching to a level where it becomes safe and reasonable for special developments to begin, and for special culture to be attempted.

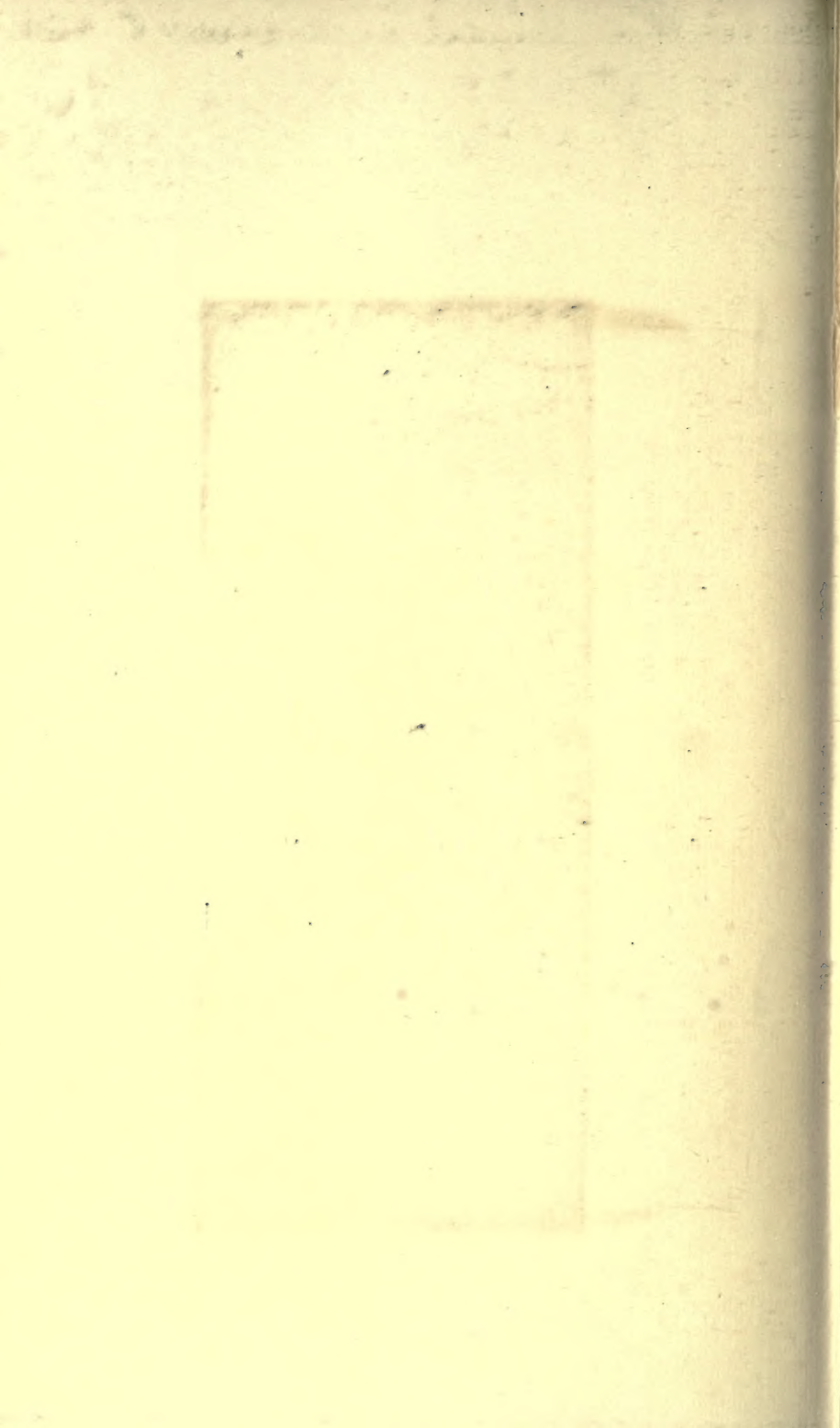
From here, it becomes possible to maintain a common connection between the special after-developments of medicine, surgery, and obstetrics, when the retention of that common connection becomes a matter of the greatest possible value in its practical bearings as a means of permitting the combined focussing of scientific opinion and the formulation of practical designs for the common advantage, thereby also preventing the divorce of specialism from the general partner, to which it was and should ever continue to be attached, and securing the joint advantages of a united progress and oneness of purpose for the general good. Furthermore, from this common level of scientific knowledge, which can be and is attained by many, if not all, for its own sake, a training has necessarily been acquired which goes far to enable the general practitioner and specialist alike to "scale the heights" and "traverse the unknown regions" that lie immediately ahead of the pioneers of science, and its utilitarian companion art, in all directions.

Thus the cohesion and continuity of scientific and practical progress in the domain of medicine in its widest, deepest, and most exact sense and bearings, is most likely to be secured and perpetuated, if it is recognised that from and to this common basis, or starting-point, all workers, scientific, practical, and dilettanti, must "shape their course" and "make their return," bringing back with them, if haply successful in their efforts, their contributions of discovery or invention to the sum of knowledge, ameliorative potentiality, and curative power.

A word on a plea for the unification and simplification of science, more especially biological science. The tendency displayed throughout the "circle of the sciences," in later times, to expedite its course, consciously or unconsciously,

has been on the part of its votaries to narrow the field of vision and to specialise the subject of investigation, until now the data available for the purposes of a general advance are in danger of being left unused and ineffective amid the constantly increasing accumulation of isolated facts, due to the cultivation of specialism.

Thus the special collections of these data in the hands of specialists, the archives of societies and institutions, and the great national museums and libraries of stored knowledge, now constitute an incalculable mass of more or less available and digested facts or material which should be capable in the hands of men in touch with the latest movements of research and discovery, of yielding great formulative results, and of conducing to the recognition of the laws by which the universe, in all its recognised parts, is governed, as well as of showing the details of its manner of working, so as to be systematised and made of practical value in the affairs of human life and work.



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